JUN 7 1923
JUN 8 1923
Chemical Library

VOL. 9. APRIL, 1923 NO. 38

JOURNAL

OF

THE INSTITUTION

OF

PETROLEUM TECHNOLOGISTS

AND

RECORD OF TRANSACTIONS.

FOUNDED 1913—INCORPORATED 1914.

PUBLISHED BY
THE INSTITUTION OF PETROLEUM TECHNOLOGISTS,
3, JOHN STREET, ADELPHI, STRAND, LONDON, W.C. 2.
AND PRINTED BY
W. SPEAIGHT AND SONS, LTD.,
98–99 FETTER LANE, LONDON, E.C. 4.

PRICE 7s. 6d.

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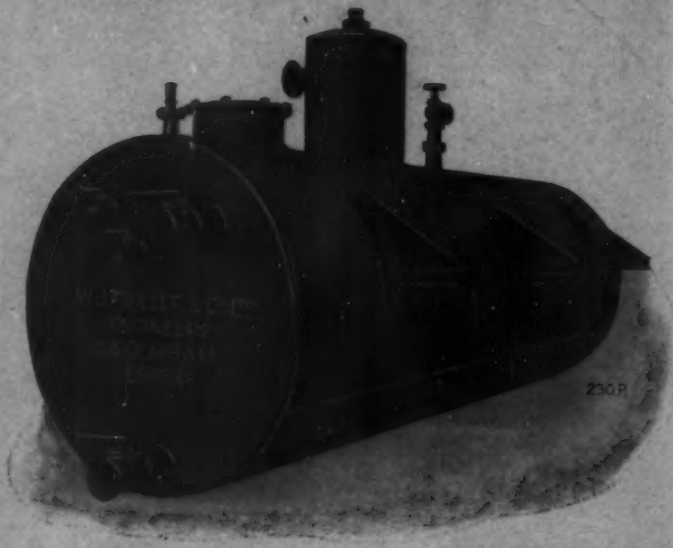

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Issue of Journal. The Journal appears in six issues per volume, viz., February, April, June, August, October, and December. A brochure describing the origin, progress and purposes of the Institution, and comprising also the Memorandum and Articles of Association, the By-Laws and Regulations of the Institution, the Library Catalogue to date (with subject index), and the List of Members, was published in September, 1915, to be followed periodically by revisions of the Library Catalogue and List of Members. The List of Members brought up to January, 1923, is now issued.

Members of all classes are entitled to receive these publications free; for additional copies of the Journal they will be charged at the price of seven shillings and sixpence per part, and of the brochures at the prices stated on the wrappers, varying in proportion to bulk.

Changes of Address. It is particularly requested that members notify the Secretary immediately of any change of address; and members are also requested to advise the Parcel Post Department, as well as the Letter Office, of any temporary change of address, as, unless this is done, parcel post packets will not be re-addressed, but will be returned to the offices of the Institution in London, thus incurring further expense for postage.

To Authors of Papers. Papers should be written in the third person and the copy should be carefully corrected by the author before it is presented.

All drawings, diagrams or other illustrations should be sent in a fit state for direct photographic reproduction.

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All quotations, technical terms and localisms should be indicated by means of inverted commas.

Foreign weights, measures and costs should be given whenever possible, and also their English equivalents.

It is suggested that authors append as complete a bibliography of the subject treated as may be possible.

All papers and notes submitted to the Institution are supposed to be original communications unless distinctly stated to be otherwise, in which case the exact reference to the previous publication should be given.

Communications upon papers read at meetings, notices of personal movements, or other matter for which publication is desired in the next issue of the Journal, should be in the hands of the Editor on or before the last day of December, March, June or September, as the case may be. Subsequent delivery may be too late for insertion.

The Council desire to draw the attention of authors to the serious increase in the cost of production. Papers, both for the Journal and for communication to the Institution, should be as concise and condensed as possible.

Communications. The Council invite members to submit papers for the forthcoming session. Communications to the Institution will, subject to the approval of the Publication Committee, be published in the Journal.

Cases for Binding. Cases for binding the Journal can now be obtained from Messrs. Wm. Speaight & Sons, Ltd., 98, Fetter Lane, London, E.C. 4, at a cost of 1s. 6d. post free. Remittance to accompany order.

Members who desire to have their Journals bound in these cases should send their Journals to Messrs. Speaight & Sons, Ltd., with an additional remittance of 3s. per volume.

This notice applies also to all previous volumes.

Reprints of Papers. Contributors of papers to the Journal are entitled to 25 free reprints of their papers, and, if desired, a further 25 copies may be had at the following rates. Orders for reprints should be sent to the printers when M.S. is forwarded to the Editor.

2 pp. ..	2s. 0d.	12 pp. ..	7s. 6d.
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8 pp. ..	5s. 0d.	20 pp. ..	12s. 6d.

Medal for Student Member. A medal and a prize of 5 guineas will be awarded annually by the Council to that Student Member of the Institution of Petroleum Technologists who shall in their opinion have presented a paper of outstanding merit during the year.

Appointments Register. A Register will be kept at the offices of the Institution for the convenience of firms requiring the services of members and for members requiring appointments, but on the distinct understanding that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library at No. 5 John Street, Adelphi, may be consulted between 11 and 4 daily. Extensive additions are being made to the current and standard literature on Petroleum.

Additions since publication of last Journal :—

Le Commerce et l'Industrie du Petrole en France. By Andre Levy.

From the Geological Survey, Scotland :

Memoirs of the Geological Survey, Scotland. Vol. 24, Cannel Coals, Lignite, and Mineral Oil in Scotland. By W. Gibson.

From the Diesel Engine Users' Association :—

Care and Maintenance of Diesel Engines. Report of Discussion. By G. E. Windeler.

From Messrs. Cull and Company :—

Map of the Mexican Oilfields. In four sheets.

From the Lloyd Library, U.S.A. :

Mycological Notes. By C. G. Lloyd. Nos. 66 and 67.

From Messrs. Chapman and Hall, Ltd. :—

The Business of Oil Production. By R. H. Johnson, L. G. Huntley, and R. E. Somers. (For review.)

From the Association of British Chemical Manufacturers :—

Official Directory of Members, with Classified List of their Manufactures, 1923.

From Messrs. Adam Hilger, Ltd. :—

Optical Methods. Vol. 1, Second Edition, Jan., 1923. By J. N. Goldsmith, S. Yudd. Lewis, and F. Twyman. (For review.)

From Messrs. the Oil Well Supply Company :—

Catalogue No. 043.

From Messrs. Negretti and Zambra :—

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From the American Petroleum Institute :—

High Cost of Gasoline and Other Petroleum Products. Hearings before Sub-Committee on Manufacturers, United States Senate. Sixty-seventh Congress, Fourth Session pursuant to S. Res. 295. Part II.

From the Colorado School of Mines :—

Supplements " A " and " B " ; Vol. 18, No. 1, Jan., 1923.

From the American Academy of Arts and Sciences :—

Proceedings, Vol. 58, No. 3. Lichenes in Insula Trinidad a professore R. Thaxter Collecti. By Edward A. Vainio.

Proceedings, Vol. 58, No. 4. The Effect of Pressure on the Electrical Resistance of Cobalt, Aluminium, Nickel, Uranium, and Cassium. By P. W. Bridgman.

From the British Engineering Standards Association :—

Complete Set of Specifications to Date.

From the Imperial Mineral Resources Bureau :—

The Mineral Industry of the British Empire and Foreign Countries. War Period (1913-1919). Strontium Minerals. Molybdenum. Silver.

From the United States Department of Commerce :—

Technologic Paper of the Bureau of Standards, No. 223 (Part of Vol. 17). Reclamation of Used Petroleum Lubricating Oils. Oct. 21st, 1922.

From the Department of the Interior, United States Geological Survey :—

Mineral Resources of the United States, 1919. ; Part I., Metals. By G. F. Loughlin. Part II., Non-Metals. By R. W. Stone.

Coke and By-Products in 1919–1920. By R. S. McBride and F. G. Tryon

Manufactured Gas and By-Products in 1920. By R. S. McBride.

Mineral Resources of the United States in 1921. Introduction by G. F. Loughlin. Statistics assembled by Martha B. Clark.

Secondary Metals in 1921. By J. P. Dunlop.

Gold, Silver, Copper, Lead, and Zinc in California and Oregon in 1921. By C. G. Yale.

Cobalt, Molybdenum, Nickel, Tantalum, Titanium, Tungsten, Radium, Uranium, and Vanadium in 1921. By F. L. Hess.

Copper in 1921. By H. A. C. Jenison.

Natural-Gas Gasoline in 1921. By E. G. Sievers.

Gold, Silver, Copper, Lead, and Zinc in Montana in 1921. By C. N. Gerry.

Gold, Silver, Copper, Lead, and Zinc in Arizona in 1921. By V. C. Heikes.

Sand and Gravel in 1921. By L. M. Beach.

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Gold, Silver, Copper, Lead, and Zinc in South Dakota and Wyoming in 1921. By C. W. Henderson.

Sulphur and Pyrites in 1921. By H. A. C. Jenison and H. M. Meyer.

Forty-Third Annual Report of the Director of the U.S. Geological Survey to the Secretary of the Interior for the Fiscal Year, ended June 30th, 1922.

Water-Supply Paper No. 473. Surface Water Supply of the United States, 1918. Part III., Ohio River Basin. By N. C. Grover.

Water-Supply Paper No. 482. Surface Water Supply of the United States, 1918. Part XII., North Pacific. Slope Drainage Basins. (A) Pacific Basins in Washington and Upper Columbia River Basin. By N. C. Grover and others.

Water-Supply Paper No. 486. Water Powers of the Cascade Range. Part IV. Wenatchee and Entail Basins. By G. L. Parker and others.

Water-Supply Paper No. 490 C. Routes to Desert Watering Places in the Lower Gila Region, Arizona. By C. P. Ross.

Water-Supply Paper No. 490 D. Routes to Desert Watering Places in the Papago Country, Arizona. By Kirk Bryan.

Water-Supply Paper No. 507. Surface Water Supply of the United States, 1919–1920. Part VII., Lower Mississippi River Basin. By N. C. Grover, and others.

Bulletin No. 201 Prospecting and Testing for Oil and Gas. By R. E. Collom.

Bulletin No. 210. Oil-Shale. An Historical, Technical, and Economic Study. By M. J. Gavin.

Bulletin No. 708. High-Grade Clays of the Eastern United States. With Notes on some Western Clays. By H. Ries, W. S. Bayley, and others.

Bulletin No. 728. The Occurrence and Uses of Peat in the United States. By E. K. Soper and C. C. Osbon.

Bulletin No. 730 D. Physiographic Provinces and Sections in Western Oklahoma and Adjacent Parts of Texas. By N. M. Fanneman.

Bulletin No. 731. Bibliography of North America Geology for 1919–1920. By J. M. Nickles.

Bulletin No. 733. Geology of the York Tin Deposits, Alaska. By E. Steidtmann and S. H. Cathcart.

Bulletin No. 735 F. General Features of the Brown Hematite Ores of Western North Carolina. By W. S. Bayley.

Bulletin No. 735 G. General Features of the Magnetite Ores of Western North Carolina and Eastern Tennessee. By W. S. Bayley.

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Bulletin No. 736 G. The Brooks, Steen, and Grand Saline Salt Domes, Smith and Van Zandt Counties, Texas. By S. Powers and O. B. Hopkins.

Bulletin No. 742. Chromite of Kenai Peninsula, Alaska. By A. C. Gill.

Technical Paper No. 323. Specifications for Petroleum Products and Methods for Testing.

Technical Paper No. 325. Natural-Gas Manual for the Home. By R. A. Cattell.

Professional Paper No. 124. The Inorganic Constituents of Marine Invertebrates. By F. W. Clarke and W. A. Wheeler.

Professional Paper No. 130. The Laramie Flora of the Denver Basin. By F. H. Knowlton.

Professional Paper No. 131 B. A Section of the Paleozoic Formations of the Grand Canyon at the Bass Trail. By L. F. Noble.

Professional Paper No. 131 C. The Shapes of Beach Pebbles. By C. K. Wentworth.

Professional Paper No. 131 D. A Geologic Reconnaissance in the Gulf Coastal Plain of Texas, near the Rio Grande. By A. C. Trowbridge.

Professional Paper No. 131 E. Preliminary Report on Fossil Vertebrates of the San Pedro Valley, Arizona. With descriptions of New Species of Rodentia and Legomorpha. By J. W. Gidley.

From the Department of Mines, Mines Brance, Canada :—

Memoir No. 129. Geology of the Moncton Map Area. By W. J. Wright.

Memoir No. 132. Geology and Ore Deposits of Salmon River District, British Columbia. By S. J. Schofield and G. Hanson.

Report of the Department of Mines for the Fiscal Year ending March 31st, 1922.

The Council would be very grateful to members who are authors of books on petroleum subjects, if they would kindly present a copy of their works to the Library of the Institution, and for review in the Journal.

The attention of members is drawn to the new supplement of the Journal which deals with current Petroleum literature. To make this section of the maximum usefulness it is necessary that there should be full co-operation between chemists, engineers and geologists, and that matter which has inadvertently escaped notice shall be immediately sent to the Editor. The Institution is indebted to Mr. W. J. Wilson for the compilation of the bibliography.

Advertisements in the Journal. A limited number of Advertisements of firms interested in the Petroleum Industry may be inserted in the Journal. Application for terms, etc., should be made to R. Donald Elcox, Advertisement Manager, Journal of the Institution of Petroleum Technologists, 5, John Street, Adelphi, Strand, London, W.C. 2.

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CHANGE OF OFFICES.

Members are requested to note that on and after June 25th, 1923, the address of the Institution's offices will be Aldine House, Bedford Street, Strand, London, W.C. 2. The offices of the Institution will be closed from 5 p.m. on Wednesday, June 20th, to 10 a.m. on Wednesday, June 27th, while this change is taking place.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that Members of the Institution send information regarding their movements to the Secretary for insertion under this heading.

Mr. F. G. RAPPOPORT has returned from Peru, and left for Siam at the end of March.

Dr. W. HOPE HENDERSON left for South America in the middle of February.

Mr. R. G. B. PRINGLE has proceeded to Lobitos, Peru.

Mr. J. A. CHILD has returned from Venezuela.

Mr. E. F. WHITTINGDALE has gone to Rumania.

Mr. GEORGE THOMSON has returned home from Abadan Persia.

Mr. C. P. HALE has returned home from Lobitos, Peru.

Mr. ARTHUR MILLAR is back home from Egypt.

Mr. A. F. STRICKLAND has proceeded to Mexico.

The address of Mr. W. HOWARD HEAD, which was omitted from the current List of Members, is 110 Cannon Street, London, E.C. 4.

All members will much appreciate the kindness of Mr. Robert Redwood in presenting to the Institution the original Redwood Viscometer. The Council have decided that the instrument shall be suitably encased, and an appropriate inscription attached.

Should any members desire to receive a Galley Proof, in advance, of papers to be read before the Institution, will they kindly inform the Secretary, and at the same time let him know the address to which the proof is to be sent.

We acknowledge the receipt of "Optical Methods in Control and Research Laboratories," by J. N. Goldsmith, Ph.D., M.Sc., F.I.C., S. Judd Lewis, D.Sc., B.Sc., F.I.C., Ph.C., and F. Twyman, F.Inst.P. Volume I. contains Spectrum Analysis, Absorption Spectra, Refractometry, and Polarimetry. Published by Adam Hilger, Ltd. The section on absorption spectra and spectrophotometry will doubtless be of interest to all petroleum chemists.

We acknowledge receipt of the directory of the Association of British Chemical Manufacturers. The publication of the new edition of the official directory of the Association of British Chemical Manufacturers for 1923 will be welcomed by all those interested in chemical industry, containing as it does a list of some 150 chemical manufacturers, with a classified list of the products which they manufacture, and including a section devoted to proprietary and trade names. The new list of products contains considerably more detail than the previous edition, and being translated into French, German, Italian, Spanish and Portuguese should be extremely useful to overseas buyers. The object of the publication is to facilitate business relations between manufacturers and chemical firms and purchasers all over the world, and the Association welcomes inquiries with regard to any particular product.

Copies of the directory may be purchased at a cost of 10s. 6d., from the offices of the Association, at 166, Piccadilly, London, W. 1.

We have received from the Anglo-American Oil Company particulars of a Press campaign designed to promote a greater measure of safety on the road, a closer spirit of friendliness, and a wider sphere of help for all those who motor for pleasure or business.

We have received the detail of Lewis's Medical and Scientific Circulating Library. The terms for subscription can be obtained from 136, Gower Street, and 24, Gower Place, London, W.C. 1.

ABSTRACTS AND BIBLIOGRAPHY.

The attention of members is called to the pagination of the Abstracts and Bibliography, which, commencing from the first Journal of Volume 9 (No. 35), are being paged separately to the remainder of the Journal.

OBITUARY NOTICE.

WALTER HENRY WILLCOX.

The Council regret to have to announce the death of Mr. W. H. Willcox, who passed away at Brockley, on March 26th, after a long and painful illness.

*****

Mr. Willcox, who was in his seventy-second year, was well-known as the Governing Director of Messrs. W. H. Willcox and Company, of Southwark, the business having been established by him in 1876, and converted into a company in 1897.

In addition to his business activities, Mr. Willcox took a great interest in public and other affairs of Southwark, and will be greatly missed by his many friends and business associates. Among other positions held by him, he was Estates Governor of Dulwich College, and was also a Member of The Worshipful Company of Leathersellers.

NOTICE.

It is proposed on two evenings next session to hold meetings devoted to the reading and discussion of short papers on "Fishing Operations" and "Shutting off water" respectively.

Members of the Institution who are interested in these topics should send in their contributions before September 30th, 1923.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.

The Sixty-ninth meeting of the Institution of Petroleum Technologists was held at the Royal Society of Arts on Tuesday evening, February 13th, 1923, the President (Prof. J. S. S. Brame, F.I.C., F.C.S.) occupying the chair.

The President, at the opening of the meeting, said that a paper would be read by Mr. G. W. E. Gibson on the subject of "Some Practical Notes on Oil Pumping." He was sure the members would cordially welcome the paper, because it was the first on that topic, which was a most important one to the industry, that had been read before the Institution. He desired to take the opportunity of pointing out that the Institution had had relatively few papers on engineering problems connected with the industry, outside the question of drilling and production, and he was quite sure that for the general information of members it was very desirable that more papers of that class should be read. He hoped his remarks would be taken as a hint by the engineering members of the Institution to get busy and forward to the Publication Committee contributions from the engineering side, in connexion with which there must be quite a number of problems of outstanding interest and importance which should be discussed.

The following paper was then read :—

Some Practical Notes on Oil Pumping

By G. W. E. Gibson,

Member "Koninklijk Instituut van Ingenieurs" (The Hague).
Member "Société de Chemie Industrielle" (Paris).

Member.

Introduction.

The art of raising water is one of the oldest of the mechanical arts, and although the ancients were not unacquainted with the physical properties of the atmosphere (the Egyptians used the siphon at least 1450 B.C.), the oldest water-raising machines acted on the "elevator" principle.

The Chinese claim to have used the "Noria" as early as 1000 B.C., and this type of "elevator"—in a modified form, it is true—is still manufactured to this day.

It is probable that the atmospheric pump dates from the seventeenth century, for it was in 1644 that Torricelli made his well-known experiments.

Prof. F. C. Lea states that the science of hydraulics had as founders Torricelli (1608–1647), and Mariotte (1620–1684), from the experimental, and Bernoulli (1700–1782) from the theoretical side.

Despite the great age of this fascinating science, there are still some phenomena of which imperfect knowledge only is available.

In view of this fact, little surprise can be felt that in regard to such a young industry as the petroleum industry, very few data are available from which the behaviour of all petroleum products can be determined with any degree of accuracy.

It is only during the last thirty years, that experiments have been made on any important scale to determine the behaviour of the flow of petroleum products in pipes, and it must be confessed that much work still remains to be done, especially in regard to that of viscous crudes and fuel oils.

One of the principal difficulties in making scientific experiments with viscous oils is the lack of similarity between laboratory conditions and those met with in industrial practice.

On the other hand, it is almost impossible to make reliable experiments of this nature in industrial plants, owing to the fact that it is most difficult to obtain stable conditions over a sufficiently lengthy period of time without interfering with the commercial organisation.

The writer has studied the difficult problem of the friction of viscous oils in pipes for several years, and has collected a certain amount of material, which he hopes to be able to communicate to the Institution at a later date. The only tests of practical value he has found so far, are those made a number of years ago by the Standard Oil Company with Californian crude, but these have not, unfortunately, been made public.

The well-known experiments of Mr. Erbiceanu in about 1910 are highly valuable and interesting, but the results are probably only applicable to fairly thin oils like the Roumanian grades that he used.

The subject is of increasing interest in the case of fuel oils, because these tend to grow more and more viscous, and it is this fact that makes many of the tests made but a short time ago valueless.

From the foregoing remarks it is evident that the whole question is by no means so easy of solution as one would at first sight be led to expect.

Unquestionably, the pumping of petroleum products provides some of the most difficult problems that the pump manufacturer is called upon to solve. In the writer's opinion an oil pump should comply with the following requirements :—

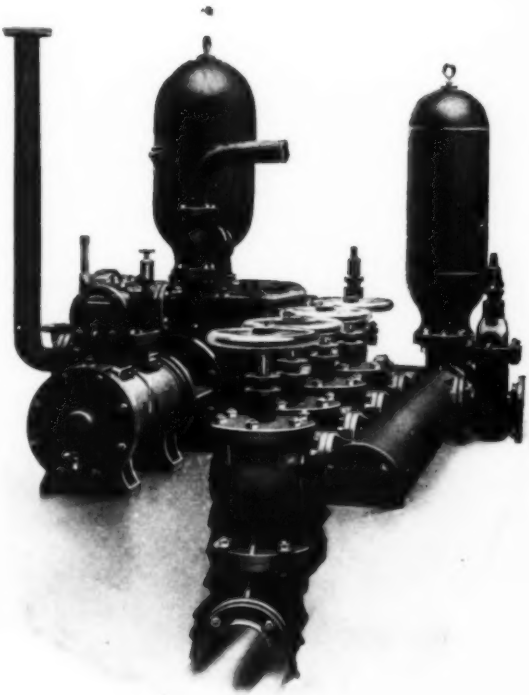


FIG. 1.

12″×12″×24″ SINGLE CYLR. CARGO PUMPS SUPPLIED IN 1888 FOR THE TANKER "VINDOBALA" (OWNER: THE LATE MR. ALFRED SUART).

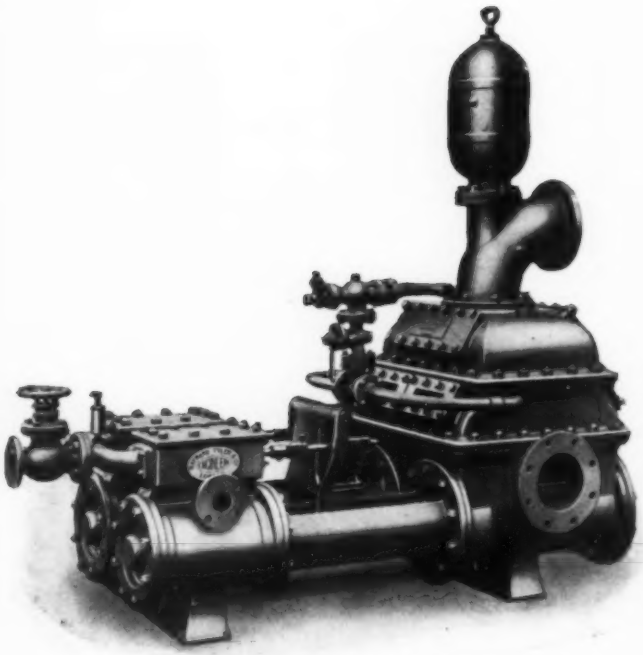


FIG. 2.

10″×10″×12″ DUPLEX CARGO PUMP MANUFACTURED IN 1890 FOR TANKERS OF THE LATE MR. ALFRED SUART.

1. Reliability.
2. Simplicity.
3. Flexibility.

In a pumping installation the pump is, however, not the sole factor to be considered, and careful thought must be given to the suction and the delivery mains.

The Suction Main.

The suction main is the part of a pumping installation requiring the utmost care and thought. When the liquid to be dealt with has been delivered into the suction chamber of the pump by the pressure of the atmosphere, the rest presents no practical difficulties whatever the delivery main conditions may be.

A little thought will make this clear. The average pressure available at sea-level for delivering the liquid into the suction chamber only equals 14·7 lbs. per square inch (1.033 kg. per sq. cm.), and this is capable of balancing a column of fresh water, 33.95 ft. high (10.33 m.). This height of suction can never be attained in practice, because no pump can produce so high a degree of vacuum—a head of 33.95 ft. equals a vacuum of 29.92 in. (760 mm.).

Due to the resistance in the suction main and the suction valves, to acceleration losses, to leakage at joints and valves, and past the buckets, and also to the liberation of the air contained in the water, in practice a total suction lift of 26 ft. (8 m.) of water should never be exceeded. In order to ensure that pumps shall be as perfect as possible in this respect, they should be tested on an actual water suction lift of 28 ft. (8.50 m.).

It should be noted that all the foregoing remarks are based on a barometer reading of 30 in. (760 m.m.), and hold good only when cold fresh water is being dealt with. This fact is sometimes lost sight of when a pump is set to work in an abnormal situation.

At an altitude of, say, 4900 ft. (1500 m.) the above named maximum practical suction lift of 26 ft. (8 m.) would be reduced to about 20 ft. (6 m.), due to the lower barometric pressure.

On a cold winter day with a high barometer it is possible to obtain over 2 ft. (0.60 m.) more suction lift than on a warm summer day.

Warm liquids cannot be dealt with under the same suction lift as cold ones, because the vapour generated tends to destroy the vacuum. Water at 150° F. (66° C.) and over, should flow into the pump under a head.

With light oils—and more especially with benzine—great care should be exercised in planning the suction mains, as due to the

high vapour tension of the gas liberated under vacuum, serious trouble may be met with, if this fact is not borne in mind.

With heavy crudes and fuel oils the trouble experienced is mostly due to the very appreciable frictional losses caused by the high viscosity of these oils, and it is necessary to make the suction main as short as possible, free from all unnecessary bends, *and of as large a diameter as circumstances permit.*

The writer has witnessed tests made with a heavy fuel oil at a temperature of 66° F.* (19° C.), with 10 ft. (3.05 m.) of vertical suction, plus 50 ft. (15.24 m.) of horizontal suction pipe, and although no trouble was experienced under these conditions, the velocity of flow was so low, due to excessive friction in a suction main of the standard size for the pump under test (4 in.), that a low volumetric efficiency was obtained.

No right angle bends or square cornered T-pieces should be used in a suction main, and it should be laid with a gradual rise towards the pump, and all places where gas can lodge should be most carefully avoided, as these naturally tend to decrease the capacity of the pump and may indeed entirely impede the delivery.

The Delivery Main.

As stated above, the forcing of the liquid through the delivery main does not present any practical difficulty, although provision for dealing with heavy pressures must frequently be provided—delivery pressures of 800 lbs. per sq. in. (56.24 kg. per sq. cm.), and even 1000 lbs. per sq. in. (70 kg. per sq. cm.) being quite common. The chief factors in determining the size of main in any given pumping installation are the prime cost and the cost of the fuel. No one would, indeed, plan an installation to work with, say, 200 lbs. per sq. in. (14 kg. per sq. cm.) delivery pressure, if by a slight additional expense—by putting in a main of larger diameter—this could be reduced to 100 lbs. per sq. in. (7 kg. per sq. cm.), with the attendant gain in fuel consumption.

One of the most important matters to be borne in mind when laying a delivery main is the avoidance of air or gas-locks or "pockets"; where it is impossible to avoid such "pockets," it may be necessary to provide means for discharging the accumulated air or gas.

Historical.

The first noteworthy Oil Pumps of which the writer has definite particulars, are the two 12 in. by 12 in. by 24 in. single cylinder pumps ordered in the year 1888 for the tanker, "Vindobala," owned by the late Mr. Alfred Suart, of London. These pumps

* Viscosity 13,000 seconds Redwood No. 1.

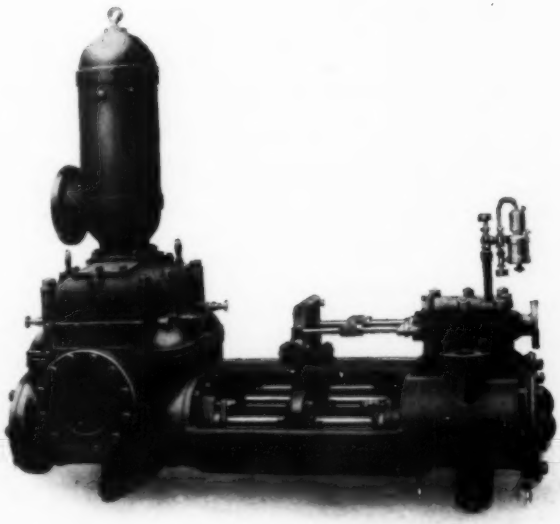


FIG. 3.

10″×10″×12″ DUPLEX CARGO PUMP—MODERN DESIGN.

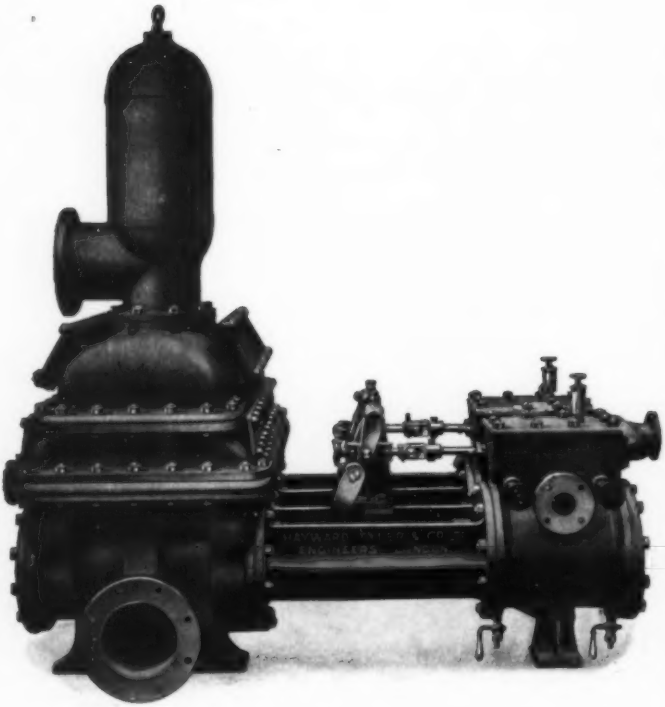


FIG. 4.

13½″×14″×12″ DUPLEX CARGO PUMP DESIGNED IN 1892 FOR THE SHELL TRANSPORT AND TRADING CO., LTD., LONDON.

(Fig. 1) were a modification of the then well-known "Universal" pump, of which the manufacture was commenced in the United Kingdom in about the year 1869, and which by that time had already won a European reputation. The modification referred to consisted of what was known as "outside-gear," that enabled the slide valve to be thrown over by hand when starting.

As will be seen from Fig. 1, these pumps were fitted with a vacuum vessel on the suction inlet, this being, of course, absolutely necessary in the case of all single-cylinder pumps, on account of the irregular and intermittent flow. During the years 1888-1890 similar pumps were supplied for the tankers, "Robert Dickinson," "Wildflower," "Prudentia," "Petrolea," "Tancarville," "Circassian Prince," "Prudence," and "Alleghany."

In 1890 the above-named ship-owner definitely decided to abandon the single-cylinder type of pump for oil pumping, and a special type of duplex pump was designed in order to combine the successful features of the single-cylinder pump with the advantages obtained by the duplex design, namely great regularity of flow and positive action. A correctly designed duplex pump will not stop when once the steam is turned on—this is not generally the case with single-cylinder pumps. The objection to the somewhat greater steam consumption of the duplex pump being more than balanced by the greater reliability, and the two most important characteristics already named.

The size of duplex pump arrived at was a 10 in by 10 in. by 12 in. (Fig. 2), a size still popular to this day. The only difference of importance between the 1890 design and that of to-day (Fig. 3) being that the latter has both the suction and the delivery valves mounted on removable solid gunmetal valve plates, the former merely having a removable valve plate for the suction valves. The pumping conditions on these early tankers were extremely onerous, as the pumps were usually fixed on the main deck and then worked with a suction lift of 23 ft. (7 m.).

The trouble experienced with gas in a pump working on a great suction lift was then, as now, fully realised, the 1890 pump being fitted, as will be seen in Fig. 2, with gas-freeing gear. A similar, but somewhat neater arrangement to the designs of Mr. R. A. Meyer, formerly Marine Superintendent of the Anglo-Saxon Petroleum Co., Ltd., is now fitted, when necessary.

Fig. 4 shows a 13½ in. by 14 in. by 12 in. duplex pump, designed and manufactured in 1892 for ss. "Turbo" of the Shell Transport and Trading Co., Ltd. (the *first* ship of that name, of course). Another installation of notable pumps of historical interest, of which full particulars are available, consists of two 21 in by 10 in. by 14 in. outside packed duplex plunger pumps, supplied in 1896 to Messrs. Akhverdoff, of Grosny (Fig. 5).

The duty was : 140 tons of crude oil (of 0.909 s.g. at 6° C.) per hour, with 60 ft. (19 m.) vertical head through 9½ miles (15½ km.) of 8 in. (203 mm.) pipe. The figures of the official test by owners' engineers, were as follows :—

Mean steam pressure	72.5 lbs. (5.1 kg. per sq. cm.).
Mean oil pressure on pumps	275 lbs. (19.33 kg. per sq. cm.).
Quantity of oil per hour	141.42 tons.
S.G. of "Naphtha" (Crude)	0.909 at 6° C.
Speed	36½ r.p.m. or 85 ft. min. piston speed.
Steam used	6140 lbs. per hour (2785 kg.).
Efficiency (pressure in pump barrel and pressure in steam cylinder) ..	82.8 per cent.
H.P. (actual)	123.

Present-Day Practice.

Duplex Steam Pumps.

For many purposes the duplex steam pump is to be preferred, for it possesses a much greater flexibility than the more economical power-driven pump, and it can safely be handled by unskilled labour. In the case of electrically-driven pumps, for example, the maximum duty for which the motor has been chosen can never be exceeded, but with the duplex steam pump generally having steam cylinders of ample size for the duty contemplated, a great variation in duty is obtained at very low cost.

As previously stated, the salient feature of the duplex steam pump, especially for dealing with petroleum products, is that it will not stop when once the steam is turned on, and that the flow of the liquid in the pipe lines is not irregular and intermittent, as is the case in all single-cylinder pumps. The provision of removable solid gunmetal valveplates in duplex oil pumps, especially in those of large size, is a most important feature in the design.

Further, there should be an entire absence of "pockets" where gas can lodge. Only the very best materials should be used in the construction of oil pumps, and all details should be of great strength to meet the onerous conditions of oil pumping.

Fig. 6 is an illustration of the 22 in. by 14 in. by 18 in. duplex oil pump, which was designed specially in 1912 for dealing with heavy Mexican fuel oil. The rated capacity of this size is 325 tons of water per hour, against a maximum delivery pressure of 250 lbs. per sq. in. Fig. 7 shows one of these duplex pumps in one of the pump rooms of ss. "San Fraterno."

For delivery pressures exceeding 250 lbs. per sq. in. (17½ kg. per sq. cm.), the outside packed plunger type of pump is to be preferred, and Fig. 8 shows such a pump. The dimensions are 23½ in. by 8½ in. by 18 in., and the duty is 75 tons of thick oil per hour against 800 lbs. per sq. in. delivery pressure (56.24 kg. per sq. cm.).

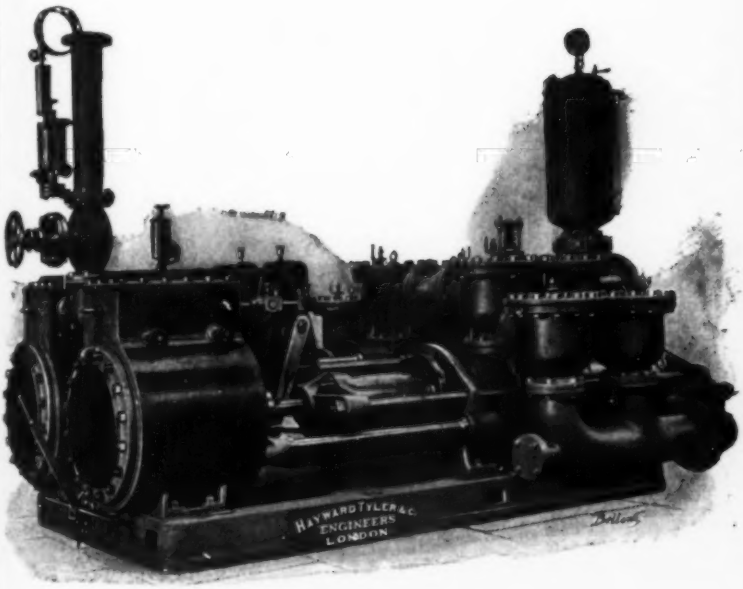


FIG. 5.

21″×10″×14″ DUPLEX OUTSIDE PACKED PLUNGER PUMPS SUPPLIED IN 1896 TO MESSRS. AKHVERDOFF, GROSNY.

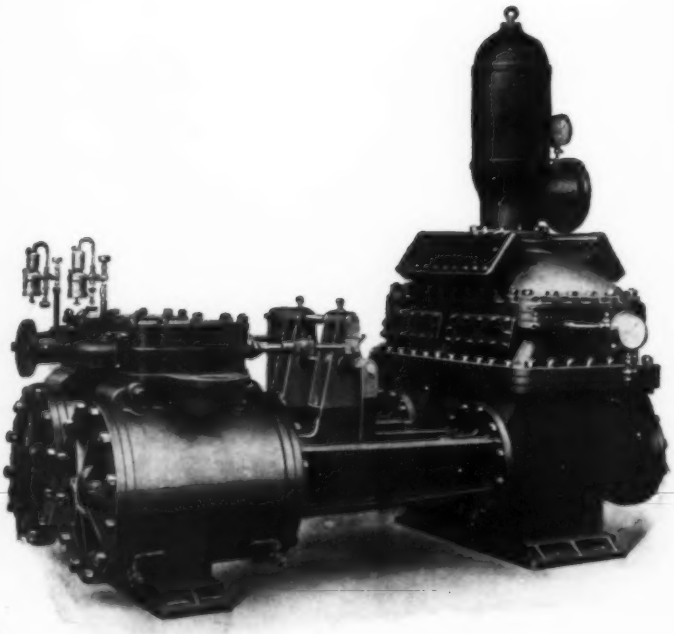


FIG. 6.

This pump is fitted with an alleviator instead of an air vessel—the latter being quite useless for pressures over, say, 300 lbs. per sq. in. (21 kg. per sq. cm.). The gunmetal suction and delivery valves are of the annular type, spring controlled, working on gunmetal seats.

In places where economy in steam consumption is a matter of especial importance, the duplex steam pump can be fitted with compound steam cylinders, with which an economy of about 20 per cent. may be obtained.

Fig. 9 shows a 14 in. and 23½ in. by 8½ in. by 18 in. compound duplex outside-packed plunger pump, duty 400,000 gallons of water (1,818,000 litres) in 24 hours against a delivery pressure of 300 lbs. (21 kg. per sq. cm.), steam pressure 120 lbs. (8.4 kg. per sq. cm.). If a sufficient supply of water is available, it is best to provide a jet or a surface-condenser.

Numerous devices have, from time to time, been patented for reducing the steam consumption of duplex pumps. Very large duplex steam pumps for pipe-line work, etc., are usually fitted with steam valves of the Corliss type, which materially reduces the steam consumption, but it should always be borne in mind that duplex steam pumps so fitted require skilled attention. Such devices are, however, quite impracticable in the case of small pumps, and this has led to a solution in another direction. A unique design in this respect is the Twells Patent Valve Motion.

Fig. 10 shows a small duplex fuel oil-pressure pump, 5 in. by 3 in. by 8 in. fitted with this gear. A duplex steam pump, fitted with the Twells Patent valve motion has a positive stroke : under no conditions whatever will trouble be experienced due to "short-stroking." The pump requires no skilled attention, and no delicate adjustments are required to be done, if it should ever be found necessary to renew any of the working parts. The gain in steam consumption is about 10 per cent., depending upon the size of the pump and the working conditions.

Duplex Power-Driven Pumps.

Power-driven pumps may be divided into two main classes : direct-driven and belt-driven pumps. The latter type presents many features of interest to the oil man, and on the whole, runs more sweetly than the direct-driven type, but, of course, it requires much more space. The driving of a number of pumps from a single large engine or motor through line-shafting, each pump pulley on the line shaft being provided with a friction coupling, in order that any pump may be stopped without interfering with the others, is perhaps the most economical solution for important

oil-pumping plants. For delivery pressures not exceeding 250 lbs. per sq. in. (17½ kg. per sq. cm.) the standard duplex oil pump can readily be arranged for power driving, and is deservedly popular.

Fig. 11 shows an 8½ in. by 12 in. oil end arranged for a direct oil engine drive through single reduction gearing. This pump delivers 75 tons of oil per hour against 50 lbs. per sq. in. delivery pressure (3.5 kg. per sq. cm.), the oil engine being capable of developing 18 to 20 b.h.p.

Fig. 12 shows a 10 in. by 12 in. duplex pump of a special type, arranged for direct coupling to an electric motor. The duty is 35,000 Imp. gallons (159,100 litres) per hour, against a delivery pressure of 200 lbs. per sq. in. (14 kg. per sq. cm.). The crankshaft runs at 45½ r.p.m., and the 120 b.h.p. induction motor (not shown) has a speed of 860 r.p.m. Each valve is contained in a separate valve box, which makes them easily accessible. These valves are of gunmetal of the annular type, spring-controlled and work on gunmetal seats.

Power-Driven Plunger Pumps.

As already pointed out, a plunger pump is to be preferred for delivery pressures over 250 lbs. per sq. in. (17½ kg. per sq. cm.), and in the case of power-driven pumps the treble-barrel plunger type is to be preferred on account of the smoothness of working.

Fig. 13 shows a 6½ in. by 9 in. horizontal electrically-driven treble-barrel plunger pump, capable of delivering 146 gallons (662 litres) per minute against a delivery pressure of 600 lbs. per sq. in. (42 kg. per sq. cm.). The crankshaft runs at 49½ r.p.m., and the 85 b.h.p. motor at 860 r.p.m.

Fig. 14 shows a pump of a similar type, but for a lighter pressure and arranged for belt-drive. The size is 9½ in. by 12 in., capable of delivering 60 tons of thick oil per hour against a delivery pressure of 400 lbs. per sq. in. (28 kg. per sq. cm.). This pump is fitted with single reduction gearing of the double helical type, and is driven by a 117 b.h.p. oil engine.

Rotary Pumps.

Although pumps of the reciprocating type are by far the most popular for dealing with petroleum products, pumps of the rotary type are now met with. They consist of the well-known centrifugal and the positive rotary types. The former are only suitable for dealing with thin oils, but the latter are more especially suitable for pumping crudes and thick fuel oils. Both types are cheap to install, but any wear that takes place may quickly reduce their efficiency.

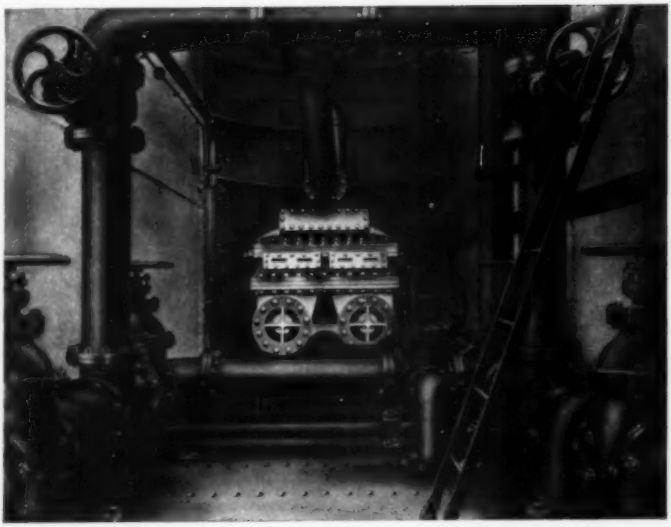


FIG. 7.

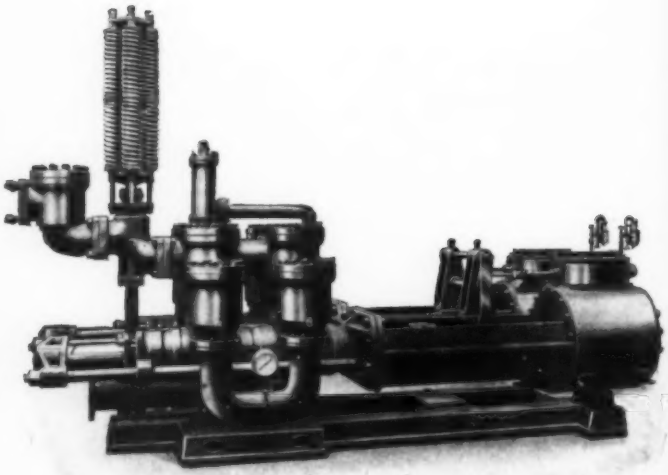


FIG. 8.

Fig. 15 shows a self-balanced turbo oil pump, capable of delivering about 180 tons of benzine (s.g. 0.700) per hour, against 53 lbs. per sq. in. (3.7 kg. per sq. cm.) delivery pressure at 680 revs. per min. Although specially designed for dealing with benzine, this pump can also handle kerosene, and water. The pump has two gunmetal runners, the shaft is of special quality nickel-steel, and the casing is split horizontally with a metal to metal joint, no jointing material being used, a most important feature in this type of pump.

Fig. 16 shows the characteristic curves of this pump when dealing with water and with benzine.

Fig. 17 shows a positive rotary pressure pump, arranged for belt drive. This type of pump is especially suitable for dealing with thick crudes and fuel oils and may be recommended for rough work on the oilfields, where pumps often have to work in exposed positions, and receive little or no skilled attention. It should be noted that this pump is fitted with a separate set of driving gear wheels, the driving of such pumps by means of the fluid rotors—as is done in the cheaper types—is to be deprecated.

Special Types of Oil Pumps.

Fig. 18 shows a horizontal treble-barrel piston pump, designed and manufactured for the Admiralty. The size is 13½ in. by 18 in., capacity 300 tons of Admiralty fuel oil per hour against 80 lbs. per sq. in. (5.6 kg. per sq. cm.) delivery pressure, or 100 tons per hour against 150 lbs. (10½ kg. per sq. cm.). The crankshaft runs at from 25 to 8½ r.p.m., and the 100 b.h.p. D.C. variable speed motor at 660 revs. per minute maximum.

Fig. 19 shows a duplex pump of a special type not designed for oil, but for a liquid that is even more difficult to pump, viz., molasses. The size is 16 in. by 12 in. by 14 in., capable of delivering 22,400 gals. (101,600 litres) of molasses per hour against 75 lbs. per sq. in. (5½ kg. per sq. cm.) delivery pressure, steam pressure, 180 lbs. (12.6 kg. per sq. cm.). The special features of this pump are the very large passages and the large valve area, the suction and delivery orifices being no less than 14 in., and the area of one valve is 57.5 sq. in. The writer considers that this type of pump is especially suitable for dealing with very thick fuel oils. It can, of course, be arranged for a power drive, if fuel economy is an important point.

Fig. 20 shows a very special type of duplex steam pump designed for pumping oil, having a temperature of 400° C. (752° F.). The size is 10 in. by 10 in. by 12 in., steam pressure 150 lbs. (10½ kg. per sq. cm.), delivery pressure, 30 lbs. (2.1 kg. per sq. cm.). The

valve boxes are made of a very close grained cast-iron of a special mixture, which gives excellent results. The steel valves are of the ball type. The pump runs for periods of three weeks without a stop. In conclusion, it may be pointed out that oil pumps should, whenever possible, be of the horizontal type, as gas troubles cannot entirely be avoided in pumps of the vertical type.

Data Required when Planning Oil Pumping Installations.

The average, minimum, and maximum temperature and the altitude of the locality where the pumping plant is to be erected. The grade of oil to be pumped—crude, benzine, kerosene, liquid fuel, etc.

Data of the Oil.—The oilfield from which the oil is obtained: Mexico, California, Baku, Rumania, Egypt, Sumatra, Borneo, etc. The minimum temperature at which it is proposed to pump the oil, and the viscosity at this temperature, preferably in seconds, Redwood No. 1 or No. 2. The maximum temperature* at which the oil is to be pumped. The specific gravity of the oil at 60° F., or at 15.5° C. The maximum quantity of oil to be pumped per hour, preferably in Imperial gallons or in litres.

Data of the Pipes.—The horizontal length of the suction pipe. Full particulars of the suction lift or suction head. The total number of bends in the suction pipe. The horizontal length of the delivery pipe. Full particulars of the delivery head. The total number of bends in the delivery pipe.

N.B.—If these pipes already exist the internal diameter should already be obtained; if not, a suitable diameter will need to be determined.

Pipe Line Pumps.—The maximum delivery pressure against which it is proposed to work. For practical reasons this usually does not exceed 800 to 1000 lbs. per sq. in. (56¼ to 70 kg. per sq. cm.).

Steam Pumps.—The minimum and maximum boiler pressure available and the distance from the boiler to the pump or the working pressure at the steam cylinder of the pump. Also, whether the pump is preferred non-condensing or condensing with jet- or surface-condenser, with single or compound cylinders.

Power-driven Pumps.—The class of prime mover that will be adopted—electric motor, steam engine, Diesel engine, semi-Diesel,

* In the case of "hot" oils this is most important. Pumps for dealing with oil at temperatures up to 400° C. (752° F.) are manufactured. See Fig. 20.

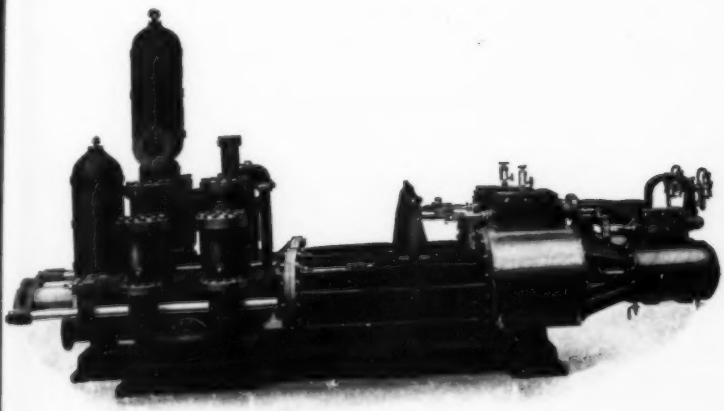


FIG. 9.

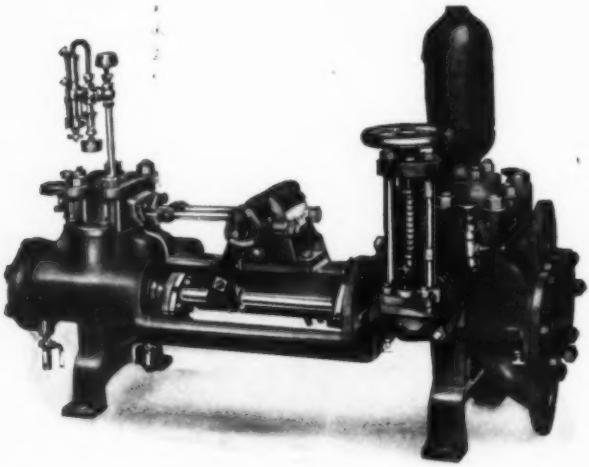


FIG. 10.

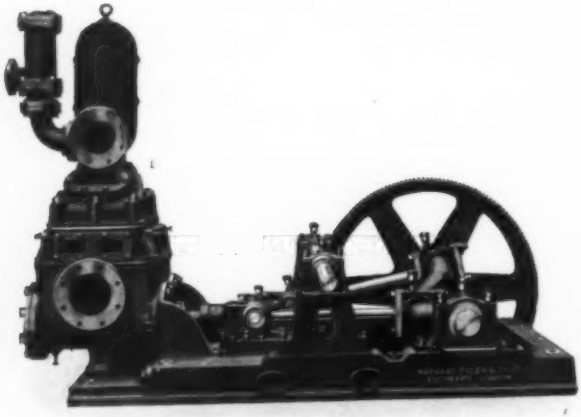


FIG. 11.

ordinary oil engine or gas engine—and the number of revolutions per minute of same. No hard and fast rules can be laid down in regard to the question of driving oil pumps direct through gearing or by means of a belt. It is largely a question of local conditions, space and sentiment. A belt drive gives a certain flexibility between prime mover and pump, considerably reducing shocks, which are unavoidable with a direct coupled set.

Speed of Pump.—If it is desired that the speed of the pump shall not exceed a certain number of revolutions per minute (or double strokes) a suitable pump has to be selected to conform to this special condition.

It is also necessary that the nature of the work to be performed should be fully known, and the number of hours that the pump has to run without a stop, in order that the best type of pump for the duty may be determined.

Note.

Listed Capacity of Oil Pumps.—Some surprise may be felt that some manufacturers invariably give the capacity of oil pumps in tons or gallons of WATER per hour in their catalogues and lists.

The reason for this is that it is utterly impossible to give the capacity of a pump for every different grade of oil and temperature. For example, it is quite misleading to give the capacity of a pump in tons of Mexican fuel oil of a definite viscosity, for then only a vague idea is formed of its capacity when dealing with, say, Rumanian crude, Tarakan fuel oil, or even Mexican fuel oil at extremes of temperature.

The writer ventures to think that by giving the capacity in WATER of a pump—a figure upon which absolute reliance can be placed—any practical oil man will himself be able to estimate the actual performance of the pump when dealing with a specific grade of oil. As a rough general guide, the writer may say that the capacity of a reciprocating pump in Imperial gallons dealing with benzine, kerosene or any other thin oil, having a lower viscosity than water, will at least equal that with water, and the speed of the pump may be as high as 40–60 double strokes (or revolutions) per minute, according to the size of the pump and the length of the stroke. Should the pump be required to run continuously for long periods, about half this speed is usually adopted. For heavy Mexican fuel and similar oils, even when adequately heated, it is not prudent to assume a capacity of more than $\frac{2}{3}$ of that with water, and as the friction in the suction line will be high, a speed of about 30 double strokes (or revolutions) per minute should seldom be exceeded.

BIBLIOGRAPHY.

In the English language :—

"Pumping Machinery." By Arthur M. Greene, Jr. (Chapman and Hall, Ltd., London.) 1919.

"Direct-Acting Steam Pumps." By F. F. Nickel. (McGraw Hill, New York and London.) 1915.

"Centrifugal Pumps." By J. W. Cameron. (Scott, Greenwood and Son, London.) 1921.

"Hydraulics and its Applications." By A. H. Gibson. (Constable and Co., Ltd., London.) 1919.

"Hydraulics." By F. C. Lea. (Edw. Arnold, London.) 1916.

"Hydrodynamics." By H. Lamb. (Cambridge University Press, Cambridge and London.) 1916.

"An Experimental Investigation of the Circumstances which determine whether the Motion of Water shall be Direct or Sinuous, and of the Law of Resistance in Parallel Channels." By Osborne Reynolds (Proc. Roy. Soc. Vol. 174, Part III.) 1883.

"A Treatise on Hydraulics." By W. C. Unwin. (Adam and Charles Black, London.) 1907.

"Hydraulics of Pipe Lines." By W. F. Durand. (Constable and Co., Ltd., London.) 1921.

"A.B.C. of Hydrodynamics." By R. de Villamil. (Spon, London.) 1912.

"Motion of Liquids." By R. de Villamil. (Spon, London.) 1914.

"Mechanics Applied to Engineering." By J. Goodman. (Longmans, Green and Co., London.) 1909.

"Applied Mechanics." By John Perry. (Cassell and Co., London.) 1909.

"General Physics for Students." By Edwin Edser. (Macmillan, London.) 1920.

In the French language :—

"Les Pompes." Par R. Masse. (Dunod, Paris.) 1903.

"Machines servant à déplacer les Fluides." Par J. Boulvin. (L. Geisler, Paris.) 1910-11.

"Les Pompes Centrifuges à Haute Pression." Par Charles Hanocq. (Ch. Béranger, Liége et Paris.) 1921.

"Cours de Mécanique-Hydraulique." Par A. Bazard. (E. Bernard, Paris.) 1908.

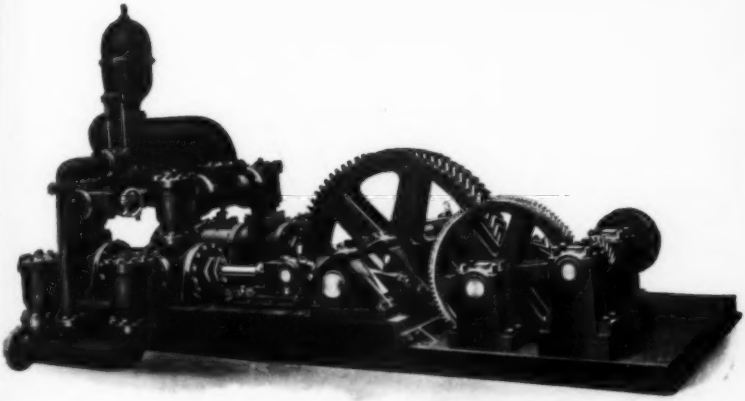


FIG. 12.

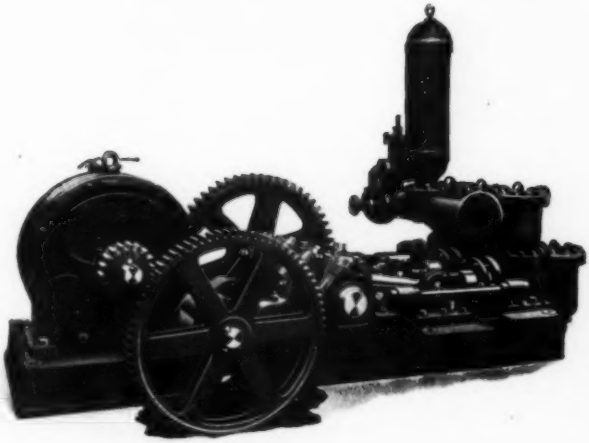


FIG. 13.

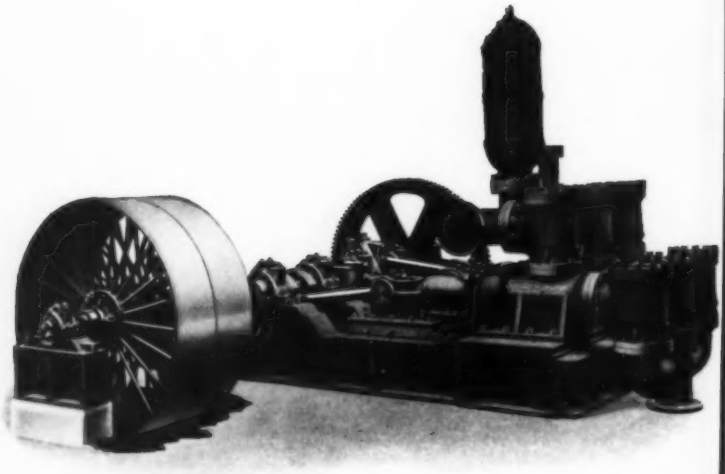


FIG. 14.

"Précis d'Hydraulique." Par G. Darrièa. (Dunod, Paris.) 1912.

"Calcul des Pertes de Charge dans les Conduites d'air, de vapeur et d'eau." Par V. Lebeau. (H. Vaillant-Carmanne, Liége.) 1922.

"A propos du Calcul des Pertes de Charge dans les Conduites Forcées." Par Charles Hanocq. (H. Vaillant-Carmanne, Liége.) 1922.

"Leçons sur la Viscosité des Liquides et des Gaz." Par M. Brillouin. (Gauthier-Villars, Paris.) 1907.

"Le Pétrole et son Industrie." Par L. Jauch. (Challamel, Paris.) 1921.

In the German language :—

"die Kolbenpumpen." Von H. Berg. (Springer, Berlin.) 1914.

"die Zentrifugalpumpen." Von F. Neumann. (Springer, Berlin.) 1912.

"Vorlesungen über Pumpenbau." Von Arthur Budau. (Carl Fromme, Wien.) 1921.

"die Kolbenpumpen." Von A. Dahme. (R. Oldenbourg, Munchen.) 1908.

"die Pumpen, ihr Bau, ihre Aufstellung und Ihr Betrieb." Von Otto Feeg. (Max Janecke, Hannover.) 1909.

"Pumpen." Von R. Vogdt. (Sammlung Göschen, Berlin.) 1915.

"Kurzgefasstes Lehrbuch der Hydraulik." Von Arthur Budau. (Carl Fromme, Wien.) 1921.

"das Erdöl." Von Engler-Höfer, Band III. (S. Hirzel, Leipzig.) 1911.

In the Dutch language :—

"Wateropvoer-Werktuigen, bewerkt naar het College van Prof. J. C. Dyxhoorn." Door G. Ferguson. (Waltman, Delft.) 1907.

"Opvoer van Vloeistoffen uit groote Diepte." Door P. N. Hoorweg. (F. J. Belinfante, 's-Gravenhage.) 1921.

"de Petroleum." Door H. Witkamp. (Tjeenk Willink, Haarlem.) 1918.

DISCUSSION.

Mr. H. Barringer, in opening the discussion, said he was sure all the members had been most interested in the paper, and they would be more interested still when they saw some of the author's figures relating to the experiments he had carried out in connexion with the viscosity of oils, because they would then be in a position to compare that data with their own. Dealing with the first section of the paper, namely, suction mains, the members knew that in pumping the shorter the main the better, but it was impossible always to make these as short as they would like. The alternative was to make them of very large diameter. It must be remembered that the area of the section of the pipe did not represent with thick oil the effective area of a column of liquid flowing through that pipe, because owing to the viscous nature of the oil it clung to the inside circumferential surface of the pipe. For that reason the spiral pipe was designed by an American with the idea of introducing a film of water between the oil and the surface of the pipe. The members were well aware that it was necessary to make the suction big, and he sympathised with the author to the extent of saying that very often it was not the pump that was at fault, but the suction mains. With reference to the question of discharge, he could not agree with the author that when a pressure of 250 lbs. was arrived at it was necessary to have a plunger pump. A very large element of friction was introduced with this type. He had in mind some single pumps, not duplex pumps, that he installed many years ago for pipe-line work with a diameter of 12 ins. and a stroke of about 30. They were driven by triple expansion cylinders, and they were fitted with a piston about 12 ins. deep that was ground to a close fit in barrel, and did excellent work at 600 lbs. to the square inch. Personally he should avoid plunger pumps wherever possible, and unless it could not be done, due to other conditions, he would put in piston pumps. One type of pump which the author had not mentioned was the pump used for the supply of fuel to burners in liquid fuel-burning boilers. In the early days small duplex pumps were used and gave a great deal of trouble; in fact they were almost unworkable with some of the oil. It was found that the solution of the difficulty was to put in a long stroke single pump, and since that principle had been adopted no trouble had been experienced. He had never seen a small duplex pump that worked satisfactorily in that position. There was one other point in connexion with the design of the pump, to which he desired to draw attention. If care was not taken in regard to some of the complicated systems of piping that were used for pumping a discharge pressure might be obtained on the suction side of the pump. Cases had occurred within his experience

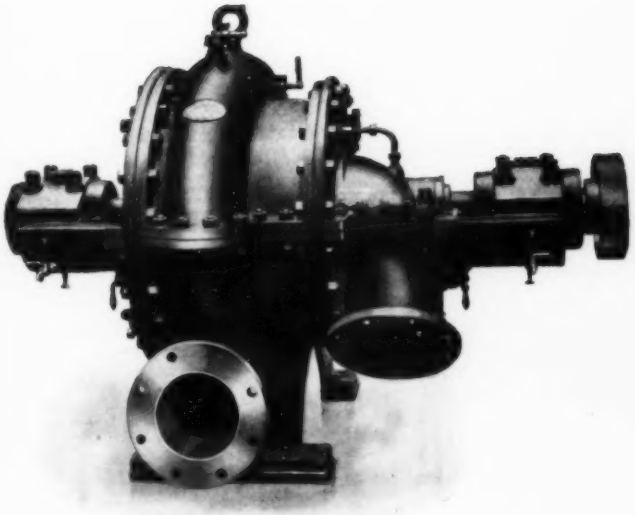
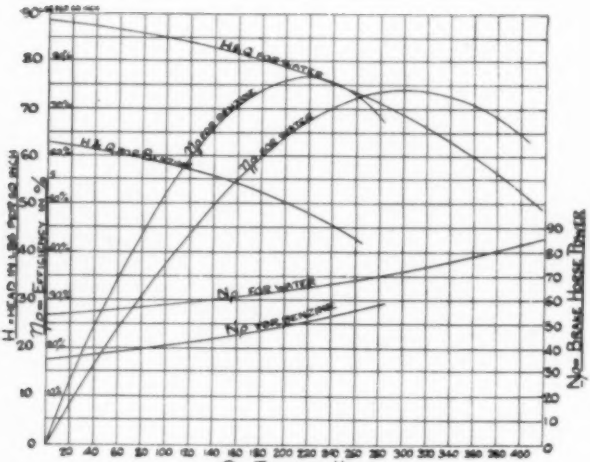


FIG. 15.


H & Q FOR SUCTION
H & Q FOR DELIVERY
ηp FOR DELIVERY
ηp FOR SUCTION
Np FOR WATER
Np FOR PETROLEUM
H = HEAD IN LBS. PER SQ. INCH
ηp = EFFICIENCY %
Np = BRAKE HORSE POWER
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400
Q = TONS PER HOUR

H = TOTAL HEAD IN LBS. PER SQ. INCH
(ie. DIFFERENCE OF GAUGE READINGS DELIVERY AND SUCTION GAUGES.)

ηp = EFFICIENCY OF PUMP
Np = BRAKE HORSE POWER

No. 50. H.T. TURBO PUMP

CONSTANT SPEED CHARACTERISTIC (680 REVS. PER MIN.)

FIG. 16

in which he had been satisfied that the suction side should be as strong in every way as the discharge side for that very reason.

Mr. N. A. Anfilogoff said that during 1922 those engaged at Thames Haven had pumped or dealt with liquid petroleum products in and out to the extent of 6000 tons per day on an average for every day of the year, so that he would be forgiven if he disagreed with the author in some of the statements he had made. Mr. Barringer had already dealt with one point that he had intended to raise. A modern single-cylinder pump was not a single-acting pump; it was a duplex pump really. It was a misnomer to call the pump which had been shown on the screen a duplex pump, because it was really a quadruplex pump. The modern single-cylinder pump acted at both ends of the piston, and there is no perceptible stoppage if the steam inlets to cylinder and proper cushioning are taken care of in the design. It was not surprising that Mr. Alfred Suart, who was the speaker's late managing director at the European Petroleum Company, threw out the single-cylinder pumps which were designed somewhere about 1880. If the design of those pumps had been a little better the probability was that they would still have been in the ships, as the single-cylinder pumps have a better suction than the duplex. He believed Worthington designed his first duplex pump somewhere about 1849 or 1850, and even at the present day, with all the science that had been brought to bear on the subject, no improvement had been made upon the Worthington pumps; they were identical to-day so far as the steam engine was concerned.

The duplex pump as a steam engine was the most uneconomical and the most wasteful product of the engineer's brain. It was true that it was expedient, and therefore the question of economy was not considered. Modern pumps had not been improved so far as the steam end was concerned, except when they were compounded. He had at Thames Haven a number of Hayward-Tyler duplex pumps at work, which were supplied to Mr. Alfred Suart in 1896-1897, and they were still giving very good service. For pumping heavy fuel oil at Thames Haven they were still using to-day the single cylinder pump, and they believed that the longer the stroke and the slower the piston speed the more efficient was the pumping. As Mr. Barringer had pointed out, in a thick oil not only was there the friction due to a viscous liquid passing over a metallic surface, but also a series of liquid frictions extending from the periphery of the pipe right to the centre. If it were possible to divide that into layers it would be found that there was a constantly diminishing rate of flow of the oil from the centre outwards towards the wall of the pipe, and that was quite natural. Using a Tipton pump of 16 in. by 12 in. by 24 in. stroke, and with an

8 in. suction and an 8 in. delivery, they were able to pump at the rate of 250 to 300 tons per hour. So far as the pump itself was concerned, where most of the makers went adrift was that instead of attempting to design their pumps in such a way that internal friction and tortuous paths within the pump itself were eliminated to the maximum possible extent, they attempted to deal with the question of the coefficients of viscosity. One type which he had in mind was made on the single-cylinder pattern, and the greatest difficulty experienced with that pump was that the valve seat had a number of webs. Other pump makers were equally guilty in that respect. The valve seat, which was driven into the pump, was 3 ins. in depth, and therefore the stream of oil coming in through the suction had to be divided into eight different orifices, so that in each case a certain amount of friction within the valve seat itself had necessarily to be overcome. On making a calculation he found that whereas the area of the 8 in. suction pipe was 50 ins., the total of the various separate areas of the suction valve seat amounted to something like 30 ins. In a case like this the pumpmakers themselves reduced the ability of the pump carrying out its work by nearly 50 per cent. The pumps were, however, now working excellently, due to the fact that they designed their own valve seat, and instead of having a multiplicity of webbs they had three ; and the total area through the valve seat now is 55 sq. ins. as against 50 ins. for the suction of the pipe. Every pump-maker tried to impress upon the user that he must have the delivery very short, and the suction shorter still, if possible. That was all very well on board a ship, but it must be remembered that the pump was at the bottom of the ship and it therefore had very little vertical lift. But when dealing with an installation ashore, in particular an installation like Thames Haven, which spread over 250 acres and contained about 300 tanks, which had to be dealt with every day, he did not think the pump-maker would have the temerity to suggest that a pump should be placed alongside each tank. It might surprise the author if he told him that it was an everyday occurrence in his experience for a pump to have to suck through 3000 feet of suction pipe and to deliver the oil or spirit 4000 feet away to either a ship or a barge at the jetty, a total of 7000 feet in all. The same thing occasionally happened, although perhaps not with quite so long a suction, with heavy thick oils, and various means were provided to enable such things to be done. The author had shown a photograph of a semi-turbo, semi-rotary, semi-centrifugal or semi-something pump—he did not know which—which he said was running at 680 revolutions per minute, and had suggested that that might be a useful pump for dealing with benzine. He, personally, would not employ a pump of that "*revolutionary*" type for pumping petrol. When the rotor was travelling through

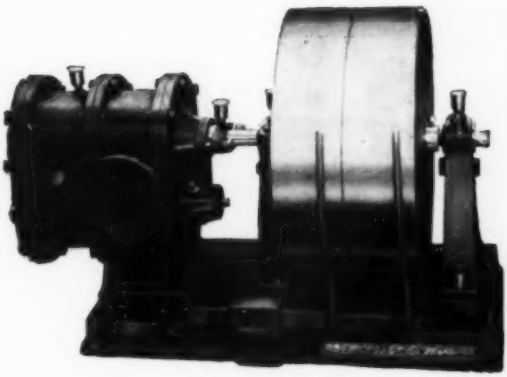


FIG. 17.

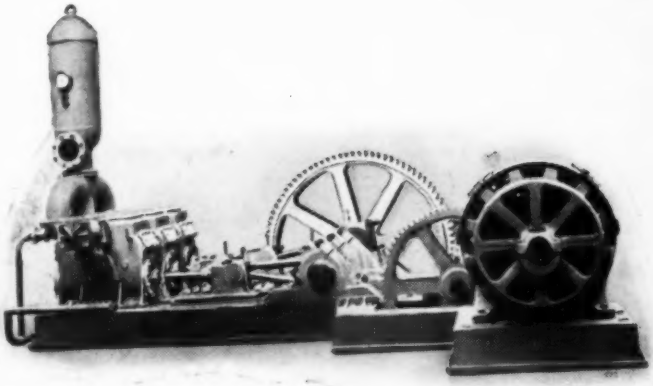


FIG. 18.

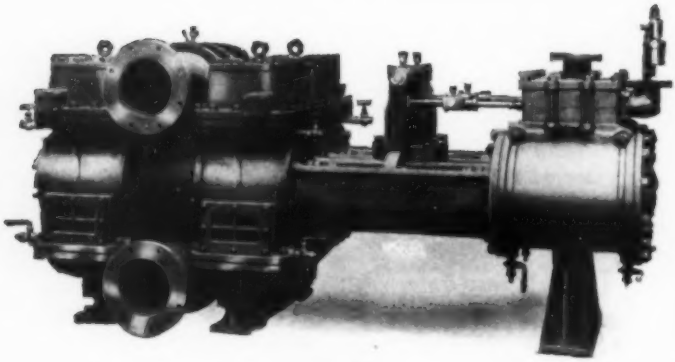


FIG. 19.

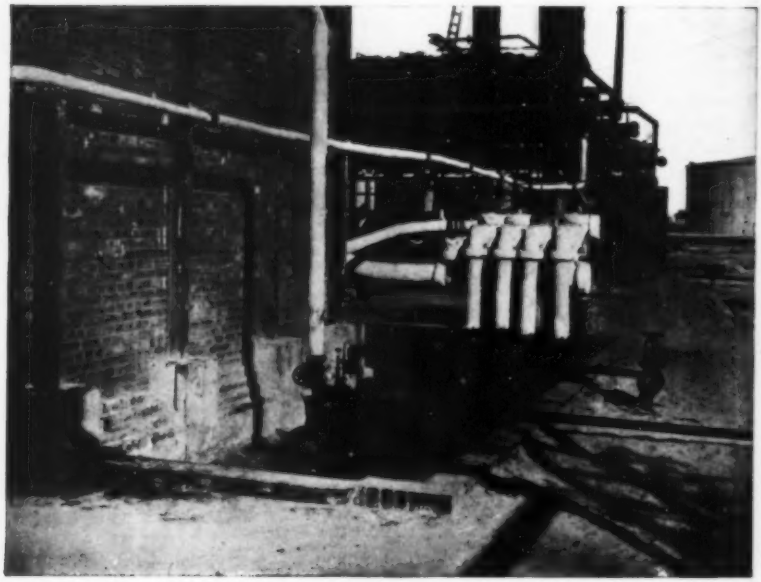


FIG. 20.

the liquid at the terrific rate of 680 revolutions a minute, unless the pump casing was earthed in all directions, he was afraid that a fire would probably occur. He quite agreed with the remarks the author had made with regard to power-driven pumps. He desired, however, to throw out a practical hint which the author had omitted in that connexion, namely, that a belt drive should not be employed when petrol was being dealt with. It would be found that cotton belts, or even leather belts for that matter, produced frictional electricity, and he had seen sparks flying from such belts. If there was the slightest leak in a gland, trouble would be caused. The leak in those cases was not due to the fault of the manufacturers of the pump, but to the user. At Thames Haven the power pumps were driven through shafts. The motor drove on to a counter-shaft inside a motor-house, which was 50 feet away from the pump-house. The counter-shaft drove on to another counter-shaft inside a pump-room, which drove all the pumps through clutches, and the power from the motor-house counter-shaft to the counter-shaft in the pump-room was conveyed by means of a rope drive, which was on the outside and not inside the pump-house.

Prof. J. W. Hinchley said in the first instance he desired to congratulate the Institution on the fact that a paper dealing with such an important chemical engineering subject as pumping had been read before it. Not only the present paper, but the second one which the author hoped to read, would add to the value of the Institution. The author had mentioned sizes of four and six inches as if the members were not capable of making exact calculations, and he also dealt with the subject of viscosity as if it was an enormously difficult one to understand. The subject of viscosity might introduce certain complications, but in the long run if it were really studied it was not such a difficult thing. The study of the suction end of a pump was very simple, and he did not see why it was necessary to talk in generalities about it. Quite a number of the problems under discussion had not yet been solved to the extent that was desirable, but many of them had been tackled and fairly reasonable solutions arrived at. There was not the slightest doubt that if they made up their minds to understand such things they would do so, so that they would be able to deal with them from exactness of scientific knowledge instead of dealing with generalities. The author had dealt with so many points, and he had further stated that he proposed to go into them more thoroughly at a later stage, that it was extraordinarily difficult to come to grips upon the important points of the paper. He thought if cost were compared carefully with commercial efficiency, different designs would very rapidly be produced by the manufacturer. Whether it was a plunger pump or a piston pump, the question was how much the user was willing to pay for it. Pumps had been designed

for working up to five tons per sq. in. for oil for small factory installations, and those pumps had given a great deal of difficulty, but he could support Mr. Barringer's statement that if a great deal of attention was paid to the actual design of the pump the use of the piston pump for higher pressures was quite feasible, and perfectly workable. On the other hand, the tremendous leakage that occurred in plunger pumps was not essential; it could be got rid of by adopting precisely the same methods that Mr. Barringer had suggested should be used for the piston pumps, *i.e.*, by making a long guide in which there was only a slight leakage of the oil. That idea was used by many different makers. Kestner, in France, had introduced a pump with a long solid piston, in which the leakage returned to the suction. He suggested that the author in his next paper should deal fully with a small portion of the subject; that in the following year he should deal with another portion of it, and so on in subsequent years, so that in the end an excellent series of papers would be obtained upon a most important subject, both to the industry of oil, and the whole of the industries of the country.

Dr. W. R. Ormandy said he desired to ask the author whether he had experienced any trouble from dissolved gases. During some recent work on flash points he had had some experience of commercial samples of ordinary kerosene which, when put in a vacuum, gave more than their own bulk of dissolved gases, and it seemed to him that that must be liable to cause trouble in cases where high lift was necessary. The author had further stated that in his opinion air vessels became useless after a time because he did not believe there was any air in them. Having recently used a very highly refined lubricating oil to close a glass tube, which was to act as a pressure gauge, it had proved necessary to make corrections every day during a period of many months because the oil, although exceedingly highly refined, dissolved the oxygen out of the air in the tube, and experience showed that it would continue to do so. It was possible to account for the fact that the oxygen disappeared out of the air chamber, but the problem still remained to be solved of what became of the nitrogen. With reference to the remarks that had been made in regard to pumping benzine, Mr. Anfilogoff had already touched upon a point upon which he desired to ask for information, namely, whether the same difficulties were experienced in pumping petrol through ranges of pipes which were experienced in the coal tar industry in pumping benzol through pipes. In that case the frictional electricity produced was of such a high order that every tar distiller knew it was absolutely essential that his pipe-line and his receiving tanks should be thoroughly earthed, otherwise trouble would ensue. With regard to the question of rotary pumps, he did not know whether there was any particular danger in using the centrifugal type of pump

for lifting petrol, but his own experience with the centrifugal pump with the variable suction lift had been that the efficiency fell off enormously with considerable variations on the suction end. Those difficulties had been very largely overcome by the use of what was known as the Rees Roturbo, and he would like to know whether the principle embodied in that and the similar Sunturbo plants had been applied to the centrifugal pumps for fluid paraffin compounds. Prof. Hinchley had referred to the theory of viscosity being pretty well known. He thought that statement applied very largely to the liquids with which Prof. Hinchley came more in contact, namely, water and salt solutions, rather than heavy oils. The point he desired to emphasise was that the question of viscosity in relation to heavy oils was one of peculiar difficulty. It was a well-known fact that if a sample of heavy oil was allowed to stand and its viscosity was taken before it was suddenly disturbed, and then after it had been merely stirred up, the two figures would differ by a very considerable amount. It must therefore be considered that the problems which the pump-maker had to overcome in pumping liquids were not quite of the easy order which Prof. Hinchley indicated, based on his experience of water and watery solutions. He thought it was just as well the audience should be reminded that problems existed in connexion with that matter, because the Institution was supposed to be a scientific and technological one, and if it were known that such problems existed it was for the members to overcome them. It was no use saying they did not exist. If they did, the members should not put their heads in the sand and say they did not exist.

Mr. E. A. Evans thought that while the photographs that had been shown on the screen were very interesting, they would have been far more instructive if the internal workings had been shown. He was not conversant with the flap valves which were shown on the screen for pumping molasses, and he would be obliged if the author could state whether it was or was not necessary that they should be lubricated when pumping this fluid. He desired to say, in the next place, that, as far as he could see from the photograph shown of the electrically-driven pump with the double-helical gearing, that no casing was used. If there was no casing he would be interested to know how the gears were lubricated. Photo No. 1889 showed the driving wheels and the pump wheels all in one case, and on the top of that casing there was a small lubricator, but whether it was a grease lubricator or a drip lubricator he did not know. He would be interested to know what system of lubrication was used, because he could hardly imagine that a drip lubricator would be sufficient for the purpose.

Mr. J. L. Chaloner said that the time available for discussion being short he proposed to refer only very briefly to two points.

Mr. Barringer had pointed out that the suction and not the pump might be one of the chief causes of any trouble that existed. In this connexion he had been wondering whether sufficient attention is paid to the design of the suction orifice. That point had been brought home to him by an interesting paper from Mr. R. W. Allen before the Institution of Mechanical Engineers. Mr. Allen had dealt with a number of novel designs of suction orifices for water, which had increased the volumetric efficiency. As had been stated during the discussion, and as members knew from practical experience, there was a considerable difference between the pumping capacity of a pump for water, as compared with oil; yet there had been indicated some relationship for the two liquids, and it was therefore quite conceivable that by a study of the suction problem on lines indicated by Mr. Allen the volumetric efficiency of a pump handling oil could be increased.

Another interesting and important point was the pump rating or capacity. In the catalogues issued by makers a number of particulars are given which are to enable users to determine the size of pump which they should install for any definite capacity. The experiments on which the data were based were said to have been made on a practical scale, but these scales, as used in the pump-makers' works had, he was afraid, very rarely any resemblance to the conditions which obtained in practice. As a result, the users were given curves and co-efficients, which when applied, produced results within practical limits of the actual conditions—sometimes. Some time ago he had occasion to compare three particular methods for determining the capacity of pumps as issued by three different sources. He found that there was a maximum difference of 43 per cent. for the pipe friction as computed by the three methods, although in one example they came within 7 per cent. of each other. Such information was, therefore, somewhat misleading, and it was important, as previous speakers had pointed out, that a common basis should be established on which the necessary tests could be carried out, and at the same time become of practical and technical value. The viscosity—with suitable allowance for the difference of the temperature in thick and thin oils—made it possible for some general relation to be established which would enable users to ascertain the pump capacity when handling oil fuel.

He desired to add his thanks to the author for having read a paper which was of very great importance to the members because it dealt with an essential accessory to the efficient distribution of liquid fuels in general. It was necessary to keep down installation and running charges, important factors from the oil user's point of view.

Mr. R. Marshall said that with regard to Mr. Anfilogoff's remarks respecting the use of leather for the belt drive, it would

be interesting to know whether the belt in question which gave off electric sparks was a leather lace belt or a metallic fastened belt, or a cemented belt. Personally, he thought there was just as much chance for the generation of static electricity from Mr. Anfilogoff's hemp rope drive as there would be from a cotton rope drive.

Mr. Anfilogoff said that most assuredly there would have been just as much chance of the generation of electricity as Mr. Marshall had mentioned, but it must be remembered that the hemp rope drive was outside and not inside the pump-room or in the motor-house.

Mr. Gibson, in reply, said that with reference to Mr. Barringer's remarks he had stated that for pressures over 250 lbs. per sq. in. plunger pumps were to be preferred. It was naturally more or less a question of sentiment and of personal opinion. He thought that for very high pressures most pumps manufactured, even of the very old types for hydraulic work, were of the plunger type. He was in entire agreement with what Mr. Barringer had said about suction mains. With regard to oil fuel burner pumps, he would like to point out that the 5 in. by 3 in. by 8 in. duplex steam-pump fitted with the Twells' Patent Valve Motion was a pump specially designed for this duty, and with this special valve motion the trouble referred to by Mr. Barringer is entirely prevented. He agreed with Mr. Barringer that the suction side of an oil pump should be made as strong as the delivery side for the reason mentioned.

He differed from Mr. Anfilogoff with regard to the working of a single-cylinder pump. There is always a perceptible pause at each end of the stroke, with a corresponding intermittent and irregular flow in the suction and delivery mains. He regretted that Mr. Anfilogoff did not state how he got over this trouble, and also over the shock in the pipe-lines. He agreed that for pumping viscous fuel oils a long stroke and a low piston speed were necessary, but not that a single-cylinder pump should be used, for the reason already stated. He further entirely agreed with what had been said about the valve seats of pumps dealing with viscous oils, and it was for that very reason that the author advocated the use of the special type of pump as Fig. 19. As Mr. Anfilogoff was aware, the reason that pump manufacturers are not always able to supply the best type of pump for a given duty is that they are often forced by the user to put in the cheapest possible design. He thought that Mr. Anfilogoff should have made it clear, when speaking of long suction mains, that in the Thames Haven and similar installations, there is usually a head on the suction. He regretted the remarks made with regard to the centrifugal pump. This type of pump has been dealing with "common or garden" benzine for many years without the slightest trouble from the cause named.

There were, moreover, numerous centrifugal pumping installations, of which Mr. Anfilogoff had presumably never heard, that were dealing quite successfully with benzine and other light oils.

He was obliged for the practical hints with regard to belt drives; they would be of great value, but if it were necessary to adopt such costly and wasteful drives, then the gain in economy by such a pumping plant might well be open to question. Was there not the fear that sparks might be caused by the clutches used? Belt drives were being used on a large scale for driving oil pumps, and with proper precautions no trouble should be experienced by frictional electricity.

He thanked Prof. Hinchley for his kind words and hoped to be able to find time to read further papers dealing with the more important points in more detail, but he is forced to disagree with Prof. Hinchley with regard to the question of the viscosity determination of viscous fuel oils. As far as the author knew no reliable figures of the absolute viscosity of viscous fuel oils existed, but he did not wish to convey the impression that viscosity was a subject difficult to understand. On the contrary it was quite a simple subject to understand, and it had long been a surprise to the author that most chemists are content to deal with it in such a highly unscientific manner. Was it not an absurdity to measure viscosity by means of seconds?

He was in agreement with the gist of many of Prof. Hinchley's further remarks, but he would like to put it in another way. The trouble did not arise from the manufacturer's patronage of ignorance, but of the users' desire to buy the cheapest possible article irrespective of efficiency or of quality. He felt sure that Prof. Hinchley would agree with him that many consulting engineers often allowed themselves to be unduly influenced by price, quite irrespective of any technical questions involved.

In reply to Dr. Ormandy he has noticed that, even when pumping, very viscous fuel oils under high vacua (say, up to 28 ins.) puffs of bluish smoke would issue from the open end of the delivery main, between the gulps of oil. Whether this was ordinary gas drawn off under the vacuum or the dissolved gas referred to by Dr. Ormandy, he did not know. This gas certainly would cause serious pumping trouble if due precautions were not taken and the pump suitably designed. The author has not experienced any trouble due to frictional electricity in benzine mains, because, possibly, the pumps and mains are usually earthed naturally. No centrifugal pump known to the author has a high efficiency over a wide range of output.

In reply to Mr. E. A. Evans he stated that the exigency of space prevents the giving of sectional views of suitable size. It is not found necessary to lubricate the flap valves of the molasses pumps

referred to. The first motion gearing (quick running) of the pumps, Figs. 12 and 18, in each case runs in an oil-bath—these had not been fitted when the photographs were taken. In the case pump, Fig. 17, the gear-wheels also run in an oil-bath and the grease lubricator is provided for use when necessity arises. The fluid rotors are in a separate chamber to the driving gear.

In reply to Mr. Chaloner, he had to say that the design of the suction inlet of all pumps is a most important feature, but it should be borne in mind that Mr. R. W. Allen was referring to centrifugal pumps, and not to reciprocating pumps; in the former the suction inlet design is most certainly a subject that required close study, and a correct design may make a very great difference to the efficiency of the pump. He quite agreed with Mr. Chaloner that many of the formulæ contained in manufacturers' catalogues were of doubtful value, and were not infrequently based on erroneous premises that were made to fit all possible conditions met with in practice.

The indiscriminate use of such formulæ, often surrounded by important-looking curves, is extremely dangerous. It is imperative in the interests of the Petroleum Industry that much of the fog that obscures the flow of viscous oils in pipes should be cleared away, and that the important work by Osborne Reynolds, Coker, Barnes, Stanton and Pannell, Perry, Lees, Duhem, Rateau, Lebeau and Hanocq, should be employed in a practical manner.

The President, after moving that a hearty vote of thanks be accorded to the author for his valuable paper, reminded the members that the Annual General Meeting of the Institution would be held at the Royal Society of Arts on Tuesday, March 13th. Due notice had been sent out to all the members, together with ballot lists for the election of the Members of Council.

The resolution of thanks having been carried by acclamation, the meeting terminated.

Mr. R. B. Grey subsequently wrote:—With reference to Mr. Gibson's interesting paper at the last meeting, it may be of general interest to know that in connexion with the friction of viscous oil in pipe-lines, a firm of pump-makers publish a set of graphs in their catalogue showing the loss of head due to friction when pumping fuel oil.

I have compared these graphs with figures obtained from an installation I recently erected, and the results in this instance are fairly accurate. The pipe-line on this installation is 10 ins. in diameter, and 2800 ft. long.

Oil Viscosity	..	1200 sec. Redwood No. 1.
Specific gravity	..	·945
Temperature	..	About 90° F.

When pumping this fuel oil at the rate of 200 tons per hour, the pumping pressure due to friction was 31·5 lbs. per sq. in., due to

allowance having been made for static head, the graph giving a pumping pressure of 32·3 lbs. per sq. in. I have not yet had an opportunity of testing the graphs on smaller diameter lines. I venture to suggest that the Institution might be able to obtain practical data on pipe-line friction losses from some of the large oil companies, who are handling oils of all viscosities, and who could, no doubt, give the pumping pressures, say, when pumping certain oil of known viscosity and temperature, through a certain diameter of pipeline of known length.

If the various data thus obtained were collated, it would be of very great practical value to those members, who, like myself, are concerned with the design and layout of pumping and pipe-line installations.

Mr. A. F. Dabell wrote :—Under "Present-Day Practice," the author declares that "the duplex steam pump is to be preferred." I would suggest that this is a retrograde step, inasmuch as the contention for the use of steam cannot be maintained on oil-fields other than those in the initial stage of development. The author, whilst granting the economy of the power-driven pump, is prepared to sacrifice such in return for the flexibility and simplicity of steam.

The advantage of flexibility in oil pumping lies in the response to the demand for temporary increased power, but this can be met by the installation of motors capable of bursting any pipe-line, whilst fitted with relief valves set to normal load. Sufficiently skilled labour for such plant is available on all established oilfields.

I advocate the scrapping of steam pumps and their replacement by the power-driven units.

The Author replied as follows :—The author thanks Mr. R. B. Grey for his written communication containing the results of a practical test, for it is by the aid of such particulars that progress will be made. The agreement between the figures obtained by Mr. Grey and those he has calculated from the graphs is interesting, but may well be more apparent than real. Much fuller and more detailed tests are necessary before any definite conclusions can be formulated.

In answer to the written communication of Mr. A. Frank Dabell the author regrets that he does not understand the meaning of these remarks. The author states in his paper that "for many purposes" the duplex steam-pump is to be preferred. The choice between steam and electrically-driven pumps is not only a technical one, but also one of first cost and of running expenses, and Mr. Dabell will no doubt agree that in many cases it would never pay to install costly electrically-driven pumps. The installing of electric motors having such a wide range of output as Mr. Dabell suggests, can, of course, only be carried out at the sacrifice of efficiency, and at a very high first cost, for which few users are prepared to pay.

ANNUAL REPORT OF THE COUNCIL, 1922.

THE Council have pleasure in presenting their Annual Report together with the Accounts to December 31st, 1922. It is a satisfaction to them that the Institution has again made substantial progress during the year.

The Membership is as follows :—

Honorary Members	8
Members	311
Associate Members	138
Students	68
Associates	36
Total	561

showing an increase of 63 over the previous record, and 14 applicants were awaiting election.

For the period under review the value of the Journals sold was £351 16s. 8d., as compared with £256 6s. 1d. for 1921.

The revenue from Advertisements is also satisfactory, being £163 10s. 8d., as against £87 18s. 2d. for the previous year, and the circulation of the Journal is now about 800 copies per issue.

The total number of copies of the Book, "The Petroleum Industry," issued is 363.

The Council have pleasure in stating that an entirely satisfactory Financial position is indicated by the Balance Sheet attached. Provision still has to be made for the expenses of the Standardization Committee's work, which is not yet completed.

The activities of the Institution have been considerably extended, and besides the numerous meetings of the Sub-Committees of the Standardization Committee, whose work was outlined in a paper read on October 10th, by Dr. A. E. Dunstan, the Institution is represented on :—

> The Conjoint Board of Scientific Societies, The British Engineering Standards Association, The Imperial Mineral Resources Bureau, The Fuel Economy Committee, British Association for the Advancement of Science, The Committee of Birmingham University which is responsible for the education of Petroleum Technologists, The 6th International Mining Exhibition, The International Air Congress, The British Empire Exhibition (1924), (Chemical Section), and official representatives attended the Meetings of the Congrés International des Combustibles Liquides held in Paris during October.

The papers read during the year were :—

At the Sixty-first General Meeting : "AN INVESTIGATION INTO THE PHYSICO-CHEMICAL SIGNIFICANCE OF FLASH-POINT TEMPERATURES," by W. R. Ormandy and E. C. Craven.

At the Sixty-second General Meeting : "THE SIGNIFICANCE OF THE INTERPRETATION OF THE CHEMICAL ANALYSES OF SEEPAGES," by J. E. Hackford.

At the Ninth Annual General Meeting : "PRESIDENTIAL ADDRESS," by Professor J. S. S. Brame.

At the Sixty-third General Meeting : "GALICIA AND ITS PETROLEUM INDUSTRY," by Albert Millar.

At the Sixty-fourth General Meeting : "KUKKERSITE, THE OIL-SHALE OF ESTHONIA," by E. H. Cunningham Craig.

At the Sixty-fifth General Meeting : "THE STANDARDIZATION OF THE TESTING OF PETROLEUM AND ITS PRODUCTS," by A. E. Dunstan.

At the Sixty-sixth General Meeting : "THE GALICIAN CANADIAN SYSTEM OF POLE TOOL DRILLING," by Albert Millar.

At the Sixty-seventh General Meeting : "SOME ASPECTS OF THE OCCURRENCE OF OIL IN RUSSIA," by T. G. Madgwick.

As showing the interest taken in the papers read, the average attendance at the Meetings during the period under review was 62 Members and 27 Visitors.

In addition the following contributions were published in the Journal :—

In Journal No. 30 : "INSULATING OILS—COLOUR AND SLUDGING CHARACTERISTICS," by E. B. Wedmore.

"COLLOID CHEMISTRY OF PETROLEUM," by A. E. Dunstan.

"THE COLLOIDAL STATE OF MATTER IN ITS RELATION TO THE ASPHALT INDUSTRY," by Clifford Richardson.

In Journal No. 31 : "THE SYSTEMS ETHYL ALCOHOL-WATER-PARAFFINS from 30° C. to —30° C.," by W. R. Ormandy and E. C. Craven.

"NOTE ON SOLUBILITY OF BENZENE IN WEAK ALCOHOL," by W. R. Ormandy and E. C. Craven.

"A METHOD FOR THE DETERMINATION OF THE VAPOUR PRESSURE OF HYDROCARBON FUELS, AND THE ESTIMATION OF DISSOLVED AIR," by H. T. Tizard and A. G. Marshall.

"WHEN OIL IS 'GOOD'," by W. F. Parish.

In Journal No. 32: "PETROLS FOR ROAD VEHICLES AND AIRCRAFT. A DISCUSSION ON THE EFFECT OF FUEL COMPOSITION UPON ENGINE PERFORMANCE," by Oliver Thornycroft.

In Journal No. 33: "THE SHALE OIL INDUSTRY OF SCOTLAND," by Edwin M. Bailey.

"NOTE ON THE EFFECT OF SMALL QUANTITIES OF VOLATILE IMPURITIES ON THE FLASH POINT OF KEROSENE," by E. C. Craven and B. G. Banks.

Mr. Herbert Barringer, M.Inst. C.E., M.I.Mech.E., M.I.N.A., has been unanimously elected President for the ensuing year.

Sir George Beilby, The Rt. Hon. Viscount Cowdray of Cowdray, Mr. Arthur W. Eastlake, and Sir Thomas H. Holland, have been unanimously re-elected as Vice-Presidents.

Mr. Alfred C. Adams and Sir John Cargill were unanimously elected Vice-Presidents for the ensuing year.

The Council has decided that "A Prize of Five Guineas and a Medal be presented by the Institution to that Student Member of the Institution who, in the opinion of the Council, presents a paper of sufficient merit in any year."

It is with great regret that the Council have to record the deaths of Mr. Louis C. Sands, Mr. George Tweedy (Founder Member), and Mr. T. H. Vaughan.

The Fourth Annual Dinner, which was held on March 21st, 1922, was a great success, over 200 Members and guests being present. Mr. Ashley Carter, the Honorary Secretary of the Dinner Club, who has so successfully carried out the arrangements for all the previous dinners, was unable to do so on this occasion owing to absence abroad, and his duties were kindly undertaken by Mr. William Sutton.

The Council desire to thank the President and Committee of the Chemical Industry Club for the hospitality which they have so courteously extended to the Dinner Club of this Institution.

The Royal Dutch Institution of Engineers, on the 75th Anniversary of their Incorporation, which took place during the year, very kindly presented a Commemoration Medal to the Institution.

The Institution is indebted to the Council of the Royal Society of Arts for their courtesy in permitting the use of their House for Meetings.

The Council have much pleasure in expressing their appreciation of the Services rendered by Sir William Plender, G.B.E., Honorary Treasurer, Messrs. Ashurst, Morris, Crisp and Company, Honorary Solicitors, Messrs. Price, Waterhouse and Company, Honorary Auditors, and Dr. A. E. Dunstan, Honorary Editor. Thanks are also due to the Secretary and his office staff for loyal services rendered.

The Honorary Auditors retire and being eligible have kindly consented to agree to their re-election.

By order of the Council,

ARTHUR W. EASTLAKE,
Honorary Secretary.

REVENUE ACCOUNT for the Year ended 31st December, 1922.

Dr.

	£	s.	d.
To Salaries	549	1	9
„ Rent, Rates, etc.	224	15	7
„ Printing and Stationery	706	4	7
„ Postage	77	19	7
„ Hire of Hall for Meetings and Expenses of Meetings	101	16	6
„ Abstracts and Reviews	145	2	2
„ Expenses *re* Publication of Book "The Petroleum Industry"	512	14	9
„ Expenses of Standardization Committee	96	11	9
„ Sundry Expenses	297	10	7
„ Depreciation of Office and Library Furniture ..	18	6	5
„ Balance carried to Balance Sheet	330	10	11
	£3060	14	7

Cr.

	£	s.	d.	£	s.	d.
By Subscriptions :—						
Members	1341	13	0			
Special	1020	0	0			
				2361	13	0
„ Interest and Dividends				84	6	9
„ Sale of Journal				279	5	10
„ Advertisements in Journal				163	10	8
„ Sale of Book "The Petroleum Industry"				171	18	4
				£3060	14	7

BALANCE SHEET as at 31st December, 1922.

LIABILITIES.

	£ s. d.	£ s. d.	£ s. d.
To CAPITAL OF THE INSTITUTION, under Bye-law Section 6, par. 14, viz.			
Life Membership Fund, per last Account	381 10 0		
Additions during year	31 10 0		
		413 0 0	
Entrance Fees, per last Account..	597 8 0		
Additions during year	107 2 0		
		704 10 0	
Donations as per last Account ..		300 0 0	
			1417 10 0
„ SUNDRY CREDITORS			102 14 4
„ SUBSCRIPTIONS PAID IN ADVANCE ..			125 14 0
„ ENTRANCE FEES PAID IN ADVANCE (pending election)			3 3 0
„ REVENUE ACCOUNT:			
Balance, 31st December, 1921 ..		1213 12 1	
Add: Arrears of Subscriptions recovered..	60 7 6		
Less: Arrears of 1921 written off	17 6 6		
		43 1 0	
		1256 13 1	
BALANCE FOR THE YEAR, AS PER REVENUE ACCOUNT		330 10 11	
			1587 4 0
			£3236 5 4

ASSETS.

	£ s. d.	£ s. d.
By INVESTMENTS, AT COST:		
£664 6 6 London County 3% Consolidated Stock	481 10 6	
£725 0 0 War Loan 5% 1929–47.. ..	659 6 4	
£50 0 0 War Bonds 5% 1927	50 0 0	
£150 0 0 Birmingham Corporation 6% Stock	146 16 0	
Note.—Market price of above Investments on 29/12/22 = £1373.		1337 12 10
„ OFFICE AND LIBRARY FURNITURE (excluding presentations) as per last Account	341 5 0	
Additions during year	27 2 6	
	368 7 6	
Less: Sales during year .. £2 0 0		
Depreciation at 5% .. 18 6 5		
	20 6 5	
		348 1 1

By LIBRARY (BOOKS) (excluding presentations) as per last Account	90	3	0			
Additions during year	20	15	0			
				110	18	0
„ SUBSCRIPTIONS (1922) OUTSTANDING AT DATE AND CONSIDERED COLLECTIBLE				38	6	6
„ SUNDRY DEBTORS				74	19	5
„ CASH ON DEPOSIT				1103	6	8
„ CASH AT BANK AND IN HAND				223	0	10
				£3236	5	4

F. W. BLACK
H. BARRINGER } *Members of Council.*

We have examined the above Balance Sheet with the Books of the Institution, and having obtained all the information and explanations we have required, we are of the opinion that such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs, according to the best of our information and the explanations given to us and as shown by the books of the Institution.

3, FREDERICK'S PLACE,
OLD JEWRY, LONDON, E.C. 2.

PRICE, WATERHOUSE & CO.

1*st February*, 1923.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

The Tenth Annual General Meeting of the Members of the Institution was held at the house of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2, on Tuesday evening, March 13th, 1923, Prof. J. S. S. Brame, F.I.C., F.C.S. (President), in the Chair.

The Secretary (Commander Rowland E. Stokes-Rees, R.N.) read the notice convening the meeting.

The President laid on the table the list of Members elected during 1922, and stated that it was available for the inspection of the Members attending the meeting.

The Secretary read the following list of Members elected as the result of the recent ballot :—

Members.—Vittorio Amoretti, Harry Roland Berry, Frederick Benjamin Crow, Albert Mayfield, Frederick Alfred Read, Murray Stuart, and Gerhardus Hendricus van Senden.

Transference from Associate Member.—Bernard Josolyns Ellis.

Transference from Associate.—Paul Nicolai Koggerman.

Associate Members.—Henry Wilfrid Barnes, Frederick L. Convers, Alfred Harold Field, William Grant, Arthur Holmes, Richard Joseph Stallard, Thomas James Swinney, and Arthur Thomas Wilford.

Transference from Student.—Albert Vernon Corlett and Francis Eric Keep.

Students.—Arthur Percy Crump, Leonard Ogilvie Dalton, Charles Wilfred Fulcher, Francis Roger Spencer Henson, and Frederick Aine Trim.

Associates.—Robert George Findlater.

The Secretary read the Minutes of the Ninth Annual General Meeting, held on Tuesday, March 14th, 1922, and they were signed as correct.

The President, in moving the adoption of the Annual Report for the year 1922, copies of which, in accordance with the bye-laws, had been circulated to all the Members, said there was hardly an item in the Report which required any special mention, but he desired particularly to refer to the announcement made towards the end of the Report, that the Royal Dutch Institution of Engineers, on the 75th Anniversary of their Incorporation, which took place

during the year, very kindly presented a Commemoration Medal to the Institution. He regretted not having asked the Secretary to bring the medal over to the meeting. Another announcement he wished to make was that, through the kindness of Mr. Robert Redwood, the Institution had received into its custody that afternoon the original Redwood Viscometer. He was sure the members would agree with him in saying that it would be one of the historical and valued possessions of the Institution, and one which it would always keep, amongst others, in remembrance of the founder of the Institution.

Mr. William Sutton formally seconded the motion for the adoption of the Report.

The President, having enquired if any members desired to make any observations on the Annual Report, and none being forthcoming, the motion: "That the Annual Report as printed and circulated, be adopted," was then put and carried unanimously.

The Secretary read the Auditors' Certificate relating to the accounts.

The President, in moving the adoption of the Accounts, said he proposed to make no comment upon them because Mr. Adams, the Chairman of the Finance Committee, was present, and he would ask that gentleman, in seconding the motion for the adoption of the Balance Sheet, to make a few explanatory remarks on some of the items which occurred in it.

Mr. Alfred C. Adams (Chairman of the Finance Committee), in seconding the motion, said it would be observed that the Membership curve followed a progressive course. Compared with the previous year, 1921, the income from members' subscriptions had increased by about £200. The number of members at the end of 1920 was 387; at the end of 1921 it was 498; and at the end of 1922 it was 561. Dealing with the debit side of the Revenue Account, the items followed very much the same course as in the previous year. The only item that called for any particular comment was: "Expenses *re* publication of book, *The Petroleum Industry*." The Council were a little disappointed that the demand for the book was not greater than had been the case. Even the members of the Institution had not ordered many copies. As stated in the Report, the number of copies sold was 363, and the financial position with regard to the book was fully disclosed in the Revenue Account now under discussion. The Council had, he thought wisely, decided that the whole of the expense connected with the book should be debited to the expenses of the year. In the next place, it would be noticed that there had been an increased income from the sale of the Journal, and also in the advertisement

revenue of the Journal, indicating that the Journal was becoming a very important publication as time went on. Turning to the Balance Sheet, it would be noticed that a small amount relating to entrance fees, and subscriptions to the Life Membership Fund, still remained to be invested at the end of the year. The amount had since been invested. The sundry creditors, amounting to £102 14s. 4d., were the ordinary floating creditors, who rendered accounts from month to month, and the particular amount in question had since been extinguished. Turning to the asset side of the account, it would be noticed that the investments were stated in the account at their cost price, although the present market price was above the figure set out in the accounts. It would also be noticed that the office and library furniture excluded presentations, and the same remark could be made with regard to the books in the library. The value of the furniture and of the library would, of course, be a great deal more than was stated in the accounts if the value of the presentations was included. The ultimate result of the balance sheet was, that at the end of the year, the Institution had a balance of income over expenditure of £330, which, added to the amount brought forward from previous years gave a balance to the credit of Revenue Account of £1,587. He thought the account showed that the Institution was in a sound financial condition, and he therefore had great pleasure in seconding the proposition that the accounts be received and adopted.

The President, before putting the motion to the meeting, enquired if any member desired to make any remarks on the Balance Sheet, or to ask any questions.

Dr. Leo Henderson thought the result of the past year's working of the Institution, from a financial point of view, was remarkable, considering the adverse times through which the petroleum industry had been passing. As Mr. Adams had stated, there was a balance of income over expenditure of £330, and if the Institution had not undertaken the publication of the book, *The Petroleum Industry*, it would have been at least another £300 better off. He would like to know how many copies of the book still remained in the possession of the Institution for sale, because a statement on that point might negative any criticism on the subject that other members might desire to make. He confessed to feeling surprised at the small amount appearing in the Revenue Account for salaries and rent, rates, etc., which showed the excellent business management the Institution possessed. He congratulated the Institution on the sound state of its finances.

Mr. A. Frank Dabell enquired how many employees were included under the heading of "Salaries, £549 1s. 9d."

The President said the staff of the Institution consisted of the Secretary and two assistants, but the salary of one assistant was charged against the work of the Standardisation Committee, so that the item of £549 included the salary of the Secretary and one assistant.

Mr. A. Frank Dabell thought that if the sum of £549 represented the whole of the salaries payable by the Institution, and if there were several servants of the Institution, in view of the fact that the balance sheet indicated that it possessed a balance of £1,587, it would be a graceful act to increase the salaries of its employees.

The President, in reply to Dr. Henderson, said there were just over 1,100 copies of the book, *The Petroleum Industry*, in the hands of the Institution. In reply to Mr. Dabell he wished to say that the Council had considered the question of the salaries, and as a result, had increased the salary of their valuable Secretary at the end of his first year of office, and they had also made an increase in May, 1922, in the salary of the assistant; so that the Council had not been unmindful of the welfare of the Secretarial Department. If there were no further comments, he would put to the meeting the motion that the balance sheet as printed and issued, be adopted.

The resolution was then put and carried unanimously.

The President said that, as a matter of form, it was necessary to re-elect the honorary auditors at each Annual General Meeting. The Council, in their Annual Report, had expressed their high appreciation of the services rendered by the honorary auditors, Messrs. Price, Waterhouse and Co., who were willing to serve again.

Mr. G. Howell formally moved the re-election of Messrs. Price, Waterhouse and Co. as honorary auditors for the ensuing year.

Mr. A. MacDougall seconded the motion, which was carried unanimously.

The President said it afforded him great pleasure to announce the result of the ballot for the Members of Council, the following gentlemen being elected :—Mr. Herbert Allen, Major R. W. Barnett, M.P., Messrs. Andrew Campbell, Ashley Carter, A. E. Chambers, Rear-Admiral P. W. Dumas, C.B., C.V.O., R.N., and Dr. F. Mollwo Perkin.

Mr. Ashley Carter and Rear-Admiral Dumas were new Members of the Council, and he was sure the older members of the Council would welcome them most heartily to the Board.

This concluded the business of the Annual General Meeting.

Presidential Address.

Prof. J. S. S. Brame.

Ladies and Gentlemen,—It is now my pleasure to deliver a valedictory address to the members of the Institution.

Before dealing with the subject matter of my address I think it may be desirable for me to refer in some way to the activities of the Institution in a less formal way than is stated in the Annual General Report. The progress and activities of the Institution have in every way been extremely satisfactory to us, speaking for the Council. In briefly referring to these activities in the past two years members must not think that I am in any way claiming any credit for the substantial progress which the Institution has made. The Institution has grown because it fills a need in the industry, because it is an active, live body, because it has done its best hrough a very businesslike Council to further in every way the commendable objects laid down in our constitution. Our growth is particularly gratifying. Mr. Adams gave the figures for the past year. I should like to refer particularly to the period of two years, dating from the end of 1920 to the end of 1922, a period characterised by very active growth. The membership in all classes increased during that period from 387 to 561, an increase of nearly 46 per cent., and our income from subscriptions increased from £830 to over £1340. As reflecting the outside interest in our Institution, the sales of our Journal have increased by 45 per cent., and the Council seldom meets without having to consider applications from other Institutions and other technical and scientific bodies publishing Journals for an exchange of publications. That, I think, is one of the most important indications of the value of the Journal. I feel that the Institution is particularly indebted to our Honorary Editor, Dr. Dunstan, for the vast amount of work which he puts into the Journal. To many of our members resident in all parts of the world the Journal is the main return which the Institution is able to give them for their support, and I do feel that the Journal has become a valuable source of information to them. During the period, or almost within the period which I am passing under review, we have had the introduction of a useful Bibliography, contributed, in the first place, by Mr. Andrew Campbell, from October, 1920, and from April, 1921, by Mr. W. J. Wilson. But what I regard as one of our most progressive steps was the introduction of Abstracts of Petroleum and Associated Subjects, which first appeared in the December issue of 1921. In future, we hope to have six issues of the Journal yearly, but if our Journal is to be all the Council hopes to see it the editor *must* have

the material for his pages, and I feel sure that members abroad can give material assistance, even although they cannot personally present their contributions to us in this room. Another matter which I should like to mention is the decision of the Council to publish a Decennial Index of the Journal next year. We feel that, as the Institution is growing, it is very desirable to have a Decennial Index compiled for the first ten years of our existence, and I have no doubt that the Decennial Indexes which will be published in future years will prove of very great value to members in turning up past papers and past information which the Journal contains.

Another point is that the Institution is being generally recognised as the constituent body in this country most competent to speak with authority on matters relating to mineral oil, and the Council will find busy spheres of activity in connexion with the Sixth International Mining Exhibition, to be held this year and the British Empire Exhibition of 1924.

Our Standardisation Committee has not yet been able to present its Report, I must admit to my disappointment, but although the main lines of the recommended methods have been settled for some months, an account was given to members by Dr. Dunstan at our first meeting of the Session, yet many little details have had to be thrashed out and some are still being debated, but I do sincerely hope that at an early date our first recommendation will be issued.

Reference to the work of the Institution would hardly be complete without some comment on the considerable changes made in our bye-laws at the last Annual General Meeting. These alterations were designed primarily to put the Institution on a more democratic basis in the hope that a greater stimulus to take a more active part in the affairs of the Institution would be imparted to the general body of members than hitherto. The seed has borne fruit, for this year, for the first time since the foundation of the Institution, we have had nominations for the Council, and we have had a ballot. Personally, I regard this as a very healthy sign—the child is beginning to find his feet. But with this change I should like to say, as the result of my experience as President, and for some period as an ordinary Member of Council, how fully I realise the consistent, and, in some cases, the continuous good work which so many members have done for the Institution. To me it always has been a striking tribute to the intuition of our first President, Sir Boverton Redwood, who certainly was responsible for choosing so many of the good men and true who have served the Institution in its days of infancy, and who will always be at its service. A surprising amount of correspondence passes through the office of the Institution. In February alone our post book shows that over 2500 communications of one sort and another

were issued by the Secretary, and it is particularly gratifying to know that people in all parts of the world are writing to him for information which they think should be in the hands of the Institution of Petroleum Technologists of Great Britain. So much for this preliminary view of the position of the Institution.

I now want to come to the subject matter of my address this evening. It is difficult for one like myself to find some suitable topic for a discourse of this description, but I finally decided that a consideration of the subject of

Fire Hazards and Fire Extinction

would be a useful matter to deal with. I trust that it will stimulate members who have had experience of oil fields and refinery fires to give their experiences to the Institution at some later date. I am sure that will give rise to fruitful discussion on this very important question. As a subject for one of the ordinary meetings of the Institution, a most instructive evening could be arranged, especially if members could illustrate their experiences with some of the very interesting photographs that I know are in the possession of many.

The problem of fire risk is one of vital importance to the great oil industry; and with the question of fire risk is naturally associated the important questions of prevention and protection, and means of dealing with oil and oil products which, in spite of every precaution, not infrequently get ablaze in some countries, though happily, very seldom in this country. From the very nature of the material oil fires present one of the most difficult types to deal with.

These questions are indeed of paramount interest in many other industries where highly combustible and often highly volatile liquids are stored, handled and used in quantity. Tar distilleries are a case in point, and other instances may be cited where highly volatile solvents are employed, in paint and varnish factories, in rubber works, in dry cleaning plants, with modern dipping methods of varnishing and of enamelling goods, and in recrystallisation from volatile inflammable solvents.

Most members of the Institution who have spent some time in the oil fields could, no doubt, give very interesting accounts of fires at wells and in storage from their experience. Everyone realises the inherent risks involved in the storage of many hundred thousand gallons of crude oil and oil products, and the great difficulty and danger in coping with an outbreak of fire, however small, when it is realised that from the small flame, or even spark, an appalling conflagration may develop. Fortunately, to-day methods of dealing with oil fires, even on a very large scale, are applicable which are so efficient that the great destruction of life and property

almost invariably associated with fires in even quite recent years has been very materially reduced. Prevention is always the soundest policy, but when all preventive measures are rendered futile by such a common occurrence as lightning, protection and extinction become first considerations. Statistics and records of fires may, at first sight, give rise to exaggerated ideas of the risks involved. I give them not in an alarmist sense—there is no occasion for alarm—but to emphasise the importance of adequate precautionary measures and to demonstrate how successful modern methods of extinction have fortunately proved themselves. Every member of this Institution realises that in this country the regulations which are laid down and the precautions which are observed by those in charge of oil storage plants and of refineries are so adequate that it is a very rare occurrence indeed for us to have any serious fires at all. But sometimes, as is exemplified in statistics from the United States, vast conflagrations have arisen. Quoting from some statistics given by C. P. Bowie (*Bulletin* 170, *United States Bureau of Mines*), I find that from January 1st, 1908, to January 1st, 1918, approximately 12,850,000 barrels of oil and 5,024,506 cub. ft. of gas were destroyed by fire. Of 503 fires reported, 310 were due to lightning. From another source (*Fuel Oil Journal*, August, 1915) I find that in Oklahoma in the three previous months 189 tanks in all were burned and one big pipe-line station. The estimated loss of crude oil was 1½ million gallons and nearly a million gallons of gasoline. It is most important to note that, of the 189 tanks, 179 owed their destruction directly or indirectly to lightning. In a period of very bad storms, in one week in the summer of 1914, lightning destroyed 86 tanks, numerous oil rigs with equipment and several field pumping stations in Oklahoma alone. Clearly protection from lightning or effects due to lightning in such areas is one of the most important considerations. Oil men so well realise the precautions vital to the preservation of their product, their plant and often their lives that seldom can carelessness be brought to their charge, and with the elimination of this "Act of God," lightning, crude oil tanks and many distillate tanks are probably no worse risk than other forms of property, in fact, it has been stated that they are a lower risk than the ordinary household.

Clearly climatic conditions and geographical situation over which man has no control are responsible for the greatest loss and danger. Man can only pit his knowledge against nature and endeavour to minimise if he cannot eliminate the risks, and make provision for coping with conflagrations where his efforts at prevention have not been successful.

A new type of fire hazard has arisen in recent years from the widely extended use of the more volatile spirit for automobiles

and many other purposes which has placed this highly inflammable spirit in the hands of thousands who little realise its inflammable nature. A paper on "Hazards in Handling Gasoline," by George A. Burrell (*Technical Paper* No. 127, *United States Bureau of Mines*, 1918) states that, in 1913, 1040 persons were burned to death, and 3120 persons injured by gasoline fires in the U.S.A. An investigation of 1000 cases of fire due to volatile liquids was made, and it was found that 771 were due to gasoline, in the large majority of cases ignition being by open flames and fires; 116 were caused by matches; 54 by electric sparks; 99 by frictional (static) electricity, and of the 140 unaccounted causes it is highly probable that sparks of frictional electricity formed a large proportion, as so frequently such a cause would be unnoticed with the sudden burst of flames.

Naturally, the volatility of the material and the explosive range over which combustible mixtures can be obtained, are most important criteria. As the members well know, wide limits for explosive range obviously increase the risk. With high volatility a mixture may be above the maximum; with low volatility a mixture may be below the minimum. With high volatility the vapour-air mixture must pass from a minimum range up to and finally beyond the maximum, so that there is a danger phase. It is possible from the vapour pressure-temperature curves to calculate the temperatures at which the lower limit and upper limit, respectively, will be reached for pure liquids, and Payman (*Jour. Soc. Chem. Ind.*, 1918, 37, 407R) gives the following results in table form:—

	Lower Limit.	Corresponding temp. C°.	Upper Limit.	Corresponding temp. C°.
Pentane	1·35	Below 0°	4·50	Below 0°
Gasoline	1·5	—	5·3	—
Pet. benzine	1·1	—	3·8	—
Benzene	1·4	−5	4·7	5
Toluene	1·4	7	4·7	30
Ethyl alcohol	4·0	15	13·6	35
Ethyl ether	1·8	Below −30	5·2	−28
Acetone	2·35	Below −20	8·5	Below −20
Carbon disulphide	4·1	„ „	—	—

With motor spirit in a limited volume of air the petrol-air mixture will soon be richer than the maximum, and, of course, although very inflammable at any escape will not fire back. In free air, where no appreciable circulation is going on, as say, with a deep open tank, there may be every gradation from an over-rich mixture at the immediate liquid surface, down to a mixture at the top which, for a time at least, is weaker than the minimum.

It is because of these considerations that the atmosphere in a closed light spirit tank is not so potentially dangerous as that in a tank with a less volatile grade of spirit, where the evaporation may

be just sufficient to form a mixture always within the explosive range.

I propose to deal quite briefly with the most dangerous product first. It will be well to consider first those things which are unlikely to cause ignition and then those which undoubtedly do cause ignition. A fairly high temperature is required to ignite petrol-air mixtures. It is said that a red-hot coal, quite free from flame; the glowing end of a match or a bright end of a vigorously smoked cigarette; sparks from scintillating fireworks, and even sparks from flint and steel generally, do not cause ignition. On the other hand, electric sparks generally will cause ignition, and one realises that any flame, as far as I know, will cause ignition; while occasionally a mechanically produced spark has also caused disaster.

A case in point was the fire which caused the death of ten persons, injury to fifteen others, and the complete wrecking of a bulk storage plant, through a negro trying to loosen a cap on a tank with a hammer and chisel. There was considerable pressure of gas in the tank at the time. An explosion and a fire occurred causing the loss of lives to which I have referred.

With regard to gasoline, the ordinary common-sense precautions adopted by all technical men in the industry have proved absolutely effective in preventing serious fires in this country whenever the rules are rigidly enforced. These include the total prohibition of naked lights or flames, or the possibility of producing flame by matches, etc.; the use of electric lights either outside the building, or double glass safety types of electric lamp inside; keeping all switches and fuses outside any building and clear of any locality where explosive vapours may reach them. Electric motors should always be of the totally enclosed type, and even then outside any danger building, and no belting likely to develop static charges should be in the building. Great attention is also necessary to electric wiring. Further, adequate ventilation is obviously one of the best safeguards in a building. In spite of all precautions, spirit offers peculiar risks, and some remarkable cases of ignition have occurred, in general due to the way in which petrol in motion can generate static electricity.

The first case of this kind which I have found is quoted in Redwood as occurring in 1890 in a tank at a leather works.

Richter noted that benzoline with friction against silk and wool developed a static charge, but not with cotton and linen. He says that temperature has a great influence; at $-15°$ C. electricity is very readily generated, at $0°$ easily, at $+15°$ C. moderately, but above $22°$ is not developed. The generation of electricity is said to be prevented by a small quantity of soap.

A few instances of ignition through static discharges may perhaps be quoted. There is the well-known instance at a London hair-

dresser's in 1897, when a spirit lotion was being used for dealing with ladies' hair. Another case was that of a workman who was cleaning his hands with a silk rag soaked in petrol. Friction gave rise to a spark, and the man was burned. Another interesting case was that of a chauffeur who was filling the tank of a car with petrol through a funnel in which chamois leather was used for filtering purposes, and to prevent the funnel tilting over he made a wood block, which insulated it electrically from the tank. Sparks were generated and the machine was destroyed. Another case occurred through the simple act of lifting a silk dress which had been cleaned with gasoline from a basket. Another case related to a chauffeur who was filling a car tank and who was wearing rubber boots and a fur coat, and the friction of the fur against the rubber boots—he was, of course, insulated from the ground—charged him with electricity to such a high potential that when he started filling his car a spark passed and the spirit was ignited. Still another case relates to a chauffeur who was drawing petrol from a self-measuring tank into a can which was provided with a wooden handle on the metal handle. He hung the can by the wooden handle and the petrol flowed into the can. It caught fire very quickly and he could not account for it. No serious conflagration took place; he threw the blazing material away and put his can back and started again, and again a fire occurred. Those are instances of the development of static charges which are, I think, of very considerable interest.

Although some of these instances are, perhaps, very exceptional yet we cannot afford to pass by the serious conditions associated with petrol in motion under some circumstances. Several fires with tank trucks have occurred when filling through rubber hose. Static electricity is probably unlikely to be developed in damp weather, and if there is proper earthing of the metal parts it is unlikely to be a danger. Where, however, a tank is not in good electrical connexion with the frame and thence to earth that connexion should be ensured. Then again, in connexion with the metal nozzle which may be attached to a filling arrangement by a rubber hose, it is very desirable that armoured rubber should be used because that will give the necessary metallic connexion between the spout and earth. Another obvious point is to have good metallic contact between the filling nozzle and the tank itself; then, of course, no possibility of a spark can arise.

It is worth while considering the case of the ordinary motor car. There you have a car which, if the tyres are dry, is electrically insulated. If petrol is flowing through rubber hose and a spout held a little distance above a receptacle and not earthed, considerable static charges may be developed. Everything is favourable. The petrol naturally charges the tank and there is a charge

on the spout. On the other hand, if the car is earthed and is therefore neutral, or if the spout is earthed, the risk of forming a spark is reduced to a minimum; but it is a most desirable precaution to have a chain connexion always between the filler and the tank itself to ensure that no spark gap shall exist, or arise.

Passing away from these particular cases referring to petrol, I would like to refer to the question of the larger size tanks. I have already mentioned that, apart from lightning dangers, large tanks filled with oil or distillates, with insistence on common-sense precautions against firing, are not bad fire risks. I think this is fully confirmed in this country by our practical immunity from fires in the many large storage depots.

Although there may be an explosive atmosphere in the top, all vents are so high that no casual person on the ground can possibly do any damage, and managers do not encourage fresh air exercise and sun baths on the tops of their tanks. Moreover, if the vents are properly protected, as they should be in every case by gauzes, on the principle of the Davy Lamp, there should be little risk of accidental ignition passing back into the tank. Here there is a point to which I think special attention should be directed, and that is, the necessity for regular inspection of these gauzes. No material in my experience rusts away more quickly than iron wire gauze, and obviously the smallest perforation renders it useless. Copper gauzes would probably be very severely attacked in a short time by sulphur-containing gases. In my opinion nickel gauze would be the best gauze for general use for this purpose.

Lightning, we have seen, obviously is the greatest risk in very many countries. I do not know whether there is an actual record of a fire in a tank in this country caused by lightning; personally I have never heard of such a case; but a very interesting report on the protection of oil tanks from lightning was made by Sir Oliver Lodge in 1918. Lodge showed how a complete metallic enclosure protected everything within its interior. He stated "An ordinary parrot cage forms a practically perfect protector." Speaking of the possible ignition of vapours at vent pipes, etc. Lodge points out the remarkable way in which sparks may be developed under high tension conditions of electrical discharge, but he considers that the completely metal tank, with good connexions throughout so that there is no possibility of sparking through charges induced in the tank, affords a very perfect protection for the interior. He is not favourably disposed towards anything in the nature of lightning conductors, and he summarises his views in this way: "It is undesirable to encourage lightning flashes in their (tanks) neighbourhood. For that reason I should not recommend the attachment of any lightning conductors to the tanks—I should not even recommend the special earthing of the

tanks. I do not want them to be regarded by the lightning as a good way to earth."

Turning now to the practice in this country, we do have the completely metal tank, but a very large number of tanks in America have wooden tops, so that there is not that continuity of metal which is desirable for perfect protection. Then, again, even with the metal top one has to guard against such possibilities as corrosion and getting faulty connexions at the tops of the tanks. The risk of ignition of wood tops and the falling back of burning wood into the oil are contingencies which have to be provided against. It is a common practice in countries where violent thunderstorms take place, and also to a limited extent in this country, to provide steam lines to the tops of the tanks, and at the approach of a thunderstorm to discharge steam freely into the tank tops. There is, of course, always the risk that if an explosion takes place the top of the tank will be blown off and probably the discharge of steam will then be of little avail.

Recently an interesting way of protecting the material in tanks from fire has been developed in America by the use of a substance known as "Sealite," which is a highly viscous fluid having the appearance of white paint, and which can be blown up by means of air to a material lighter than the oil, so that it will float on the surface. It can be inflated as it were by air bubbles, and it will set in a semi-solid mass on top of the oil. The liquid which is used for preparing the material consists essentially of a solution of glucose, glycerine, a certain quantity of calcium chloride to keep a definite degree of moisture, and some glue, and with it is incorporated a certain proportion of starch. The mixed solution weighs about 11 lbs. to the gallon, and when it has been beaten up with air a fluid is obtained which weighs about 4.75 lbs. to the gallon. This has been pumped into the oil tanks, where it floats on the oil or petrol and forms a layer an inch or two thick on top of the oil. That serves in the first place to seal the oil from evaporation, and it is also claimed that it acts as an effective fire preventer. Experimental tanks of oil and gasoline, with explosive mixtures introduced and the gasoline covered with Sealite, have been fired and the top blown off the tank, but no ignition of the liquid occurred. Shavings, paper and wood have been lit on the Sealite; this has melted and the burning material sank through, igniting the oil momentarily, but the Sealite flowed over the gap and extinguished the fire. There are certain limitations to this material. For instance, it is said to have a limited life of one year, but improvements are being made in its composition. Another difficulty is that the material is water soluble, so that it is not applicable in certain cases. Another difficulty would arise if, as is probably the case, the Sealite adheres pretty firmly on the sides of the tank and does not float up and down

with the change of oil level. Sealite has been developed by the Development Department of the Standard Oil Company of New Jersey, and the first commercial plant was started in New Jersey in the Spring of 1922. It seems to me that it is quite possible to improve on that material by making the froth with carbon dioxide instead of with air if such a composition can be adopted that the carbon dioxide does not combine with any of the necessary constituents of the material.

I should now like to pass briefly in review some of the other methods by means of which fire may be prevented. First of all, it would be most natural, perhaps, to deal with what may be termed extinctive atmospheres. We know that if the vapours of the oil cannot get air they cannot burn. We also know that it does not require a very great reduction in the amount of oxygen present in the atmosphere to prevent combustion occurring. Burgess and Wheeler have shown that with the gas methane, which occurs in such large quantities in natural gases, as soon as the oxygen is reduced to 13½ per cent. the methane flame is extinguished Practically the same result has been obtained with other hydro-carbon gases. Taking the range from methane to pentane, the first five hydro-carbons of the paraffin series, extinction is reached with about 16.3 to 16.6 per cent. of oxygen ; so that you see how very quickly the atmosphere would be exhausted of sufficient oxygen to maintain combustion if you could only shut out excess of air. Another method is to use with the air some well-known extinguishing gas like carbon dioxide. There is a large installation of oil tanks at Hamburg, which is provided with pipe lines from a storage of carbon dioxide, so that this gas can be used in the tanks should any accident occur. There is also a line of Scandinavian oil tankers, in which carbon dioxide is provided for the same purpose. Of course, the application of gases would probably be of little use in the open, but in closed spaces comparatively small quantities of carbon dioxide and sulphur dioxide should prove effective.

Our usual agent for dealing with fire—water—is generally recognised as very inefficient in connexion with oil fires, in fact very often it is an added danger. If you can use it in sufficient quantity it may have a cooling effect and reduce the temperature below the temperature of ignition of oil, and it will also act, if converted into steam, as an extinctive atmosphere. One volume of water at 100° will give about 1250 volumes of steam at 100°, and probably at the temperature of most fires we might expect at least 2000 volumes of steam, so that the steam may have a very big blanketing effect. But there is the great danger with oil that it may be washed about and carried in a burning condition some distance on the water. Although water applied more or less in mass may have these disadvantages, I think that the application

of water in the form of a very fine spray might possibly give very different results and cause the extinction of a fire if sprayed on top of oil when it is blazing. It is interesting to note that in a German patent the idea of spraying water as a mist by means of high pressure steam on to oil is claimed. The only information I have been able to obtain with regard to that is that a petrol fire of 1200 cubic yards was extinguished in five minutes using only 40 lbs. of steam at 200 lbs. pressure. What a fire of "1200 cubic yards" is meant to imply I cannot quite grasp. Authorities, of course, often insist on a ring of hydrant connections round tanks. In some cases it is questionable if the tanks were on fire whether people could get to the hydrants to make use of them. They would probably be of no value in extinguishing a fire in a particular tank, but they are undoubtedly of great value from the point of view of keeping neighbouring tanks cool and preventing them from taking fire. Then again, water-top tanks are sometimes used, and other systems favour a water curtain sprayed over the top of the tank. It is interesting to note that Watson-Smith many years ago, in considering fire in connexion with tar distilleries, suggested that the ammonical liquor in the tar works would be far more effective than ordinary water in extinguishing fire.

Passing away from water, I should like next to deal with other smothering agents such as sand and sawdust mixtures. The use of sand is well known. Sand is usually provided for dealing with small fires. It is excellent where oil has been spilled and is burning in comparatively shallow masses; but where there is any depth of oil, of course, the sand very quickly sinks and is not effective. For that reason sawdust has been introduced, and sawdust even alone acts as an excellent blanketing arrangement. It is improved considerably, however, by incorporation with bicarbonate of soda, because the latter gives off carbon dioxide under the action of heat. The British Fire Prevention Committee recommended for small garages the use of a mixture consisting of 10 lbs. of bicarbonate of soda per bushel basket of about 12 lbs. of sawdust. Fuller's earth mixed with bicarbonate of soda is also claimed to be an excellent material for this purpose.

The next type of material for dealing with fires which I will mention is the use of special chemical fire-extinguishing agents. The first suggestion with which I am acquainted was for the use of chloroform in 1875, by Ommergauch, a most remarkable liquid to suggest for this purpose; and later, in 1911, Breslauer suggested the use of a solution of bromine in carbon tetrachloride. Some of us have more than a nodding acquaintance with bromine, and I am sure we would not like to be in the neighbourhood when a solution of bromine in carbon tetrachloride was used for fire extinction purposes. Davidson (*Eng. Pat.* No. 3704) proposed to dissolve

carbon dioxide, sulphur dioxide and hydrochloric acid gas in carbon tetrachloride, presumably on the principle that if one does not serve the purpose in a particular fire the other one will. All sorts of mixtures have been suggested from time to time, such as aniline in acetylene tetrabromide, bromoform in trichloroethylene, but the cost would, in most cases, be prohibitive. In 1906, W. Graff and Co. patented the oxy-halides of sulphur, for example, sulphuryl chloride. Again, we should not care to be in the vicinity when that is used. Then there is carbon tetrachloride which is used in certain well-known brands of chemical fire extinguishers, and which is an extremely useful agent for dealing with small fires. Many garages and many distilleries are provided with carbon tetrachloride fire-fighting appliances. The specific gravity of this liquid is 1.632 at 0° C.; its boiling point is 77° C., and its vapour is heavy, about 5½ times as heavy as air, so that it acts as a very good fire extinguishing agent. When sprayed on the fire it produces a dense black smoke and pungent fumes, a mixture of hydrochloric acid and chlorine, which has to be guarded against in the case of badly ventilated places, and carbon tetrachloride itself has a considerable toxic effect. In many ways chemically and physically, it is very closely allied to chloroform, and experiments which were carried out at the National Physical Laboratory demonstrated the necessity of care being exercised when carbon tetrachloride was used at all freely in badly ventilated places. Some people are particularly susceptible to the vapours of that substance.

The ordinary type of extinguisher in which carbon dioxide under pressure sprays water charged with carbon dioxide on to the fire hardly calls for comment in this connexion. It is little more than a means of getting a small quantity of water there, and it is of very little use for oil fires.

Turning to a consideration of the well-known foam methods of dealing with fires, we come to methods which have in recent years proved highly effective for this purpose. In 1911 an investigation was made by the Prussian Fire Brigade of a caustic soda solution, which contained froth-forming ingredients and a solution of alum and other chemicals which were mixed by carbon dioxide. In 1914 the well-known patents of J. B. Erwin and R. Erwin were taken out. All sorts of mixtures have been used for this purpose, but broadly speaking, we may say that the root idea has been to use an acid solution in one tank and a solution of bicarbonate of soda in another tank, and in order that the foam shall be persistent various materials are dissolved in the solutions. All kinds of suggestions in the way of materials have been made, such, for instance, as extract of liquorice, glue and glucose, saponin and quillaia bark, for the purpose of giving the necessary consistence to the froth. There is one important consideration to be borne in

mind, namely, that many of these organic bodies undergo decomposition when they are kept, so that one frequently finds that preservatives are added. Salicylic acid is used in some, and even white arsenic solution is used in one of these mixtures in order to preserve the foam-forming constituents. It is very important, because of the possible deterioration of the foam-forming material, that weekly tests shall be made with small quantities drawn off from the tanks in order to be quite sure that the material is in a good and active condition. There is probably very little to choose between the different solutions which are covered by different patents. It is the successful application of the foam in the best condition, and with sufficient rapidity, which is of primary importance, and there, of course, experience in design of the plant is a necessary factor. Most of these solutions contain sulphate of alumina, and that contributes materially to the success of the foam, because sulphate of alumina when it is acted on by carbonate of soda precipitates out the well-known hydrate of alumina, which is a very gelatinous substance and which serves to stiffen the foam. One important point which must be borne in mind is the corrosive nature of the acid solution. In many systems a dry pipe system is employed so as to avoid great lengths of pipe which would have to be lead-lined in order to prevent corrosion going on at a rapid rate inside, so that, as a rule, a very short length of pipe serves to connect the acid solution with the control valve. This may be lead lined or, it is claimed, a brass pipe does equally well. The valve seating and valve is frequently made of an alloy containing 95 per cent. of lead and 5 per cent. of antimony. To guard against corrosion after use it is quite common to provide means for washing out the pipe-lines with water or with lime water, or passing a quantity of the alkaline solution through the acid pipe-lines. Many of these systems are now made with automatic discharges operated by fusible metal devices. One volume of the acid solution and one volume of the alkaline solution should give something like 15 or 16 volumes of foam. On this basis a quarter of a gallon of each solution would give a foam six inches in depth per square foot of oil surface. The following table shows the composition of three froth liquids as published in Bulletin 170 of the United States Bureau of Mines :—

At Coalinga.

A.		B	
Water (by wt.)	100	Water (by wt.)	100
Aluminium sulphate crystals	10	Sodium bicarbonate	7½
Sulphuric acid 66° Be	½	Glue	1½
		Glucose	½
		Arsenic trioxide	$\frac{1}{64}$
Water	100	Water	100
Aluminium sulphate	14	Sodium bicarbonate	9½
Licquorice root extract	3		

Water		100	Water		100
Aluminium sulphate	..	12	Sodium bicarbonate	..	10
Acetic acid	.. ..	½	Ground glue	.. ..	1
Ground glue	.. ..	1	Glucose	.. .. ..	½
Glucose	.. .. ..	½			

In a cylindrical vessel, 11 in. diameter, with 15 litres of foam, there was a

4	per	cent	loss	of	volume	in	4	mins.
10	,,	,,	,,	,,	,,	,,	10	,,
41	,,	,,	,,	,,	,,	,,	30	,,
67	,,	,,	,,	,,	,,	,,	60	,,

On water the foam lasted better, but only 11 litres was formed, there was no appreciable loss in 10 minutes. There was an

8	per	cent	loss	of	volume	in	20	mins.
20	,,	,,	,,	,,	,,	,,	30	,,
45	,,	,,	,,	,,	,,	,,	60	,,

On "benzine"—13 litres of foam, there was a

5	per	cent	loss	of	volume	in	5	mins.
14	,,	,,	,,	,,	,,	,,	10	,,
47	,,	,,	,,	,,	,,	,,	30	,,
76	,,	,,	,,	,,	,,	,,	60	,,

These systems have been applied very successfully to smothering conflagrations on a very large scale. I have heard the objection raised to the foam systems that if an explosion takes place probably the mixing tank in which the solutions come together at the top of the big oil tank will be blown away. That is a fault of design. In properly designed systems these tanks are so situated at the side of the main oil tank that such a contingency is unlikely to arise. A very big installation has been erected at Coalinga to deal with four 55,000 barrel tanks, one 37,000 barrel and one 30,000 barrel tanks, and two fuel oil tanks 8 feet in diameter. To give each 55,000 barrel tank a 5-inch layer of foam in 5 minutes, 550 gallons of the two liquids would have to be pumped, and to provide for all the tanks the capacity of each solution tank was 15,700 gallons. The tanks had a suction pipe 3 inches from the bottom, and the soda tank a drain at the bottom. The acid tank was lead lined and had a depression half an inch deep by 12 inches in diameter in the bottom, so that the acid below the level of the suction could be syphoned off when the tank had been emptied, so avoiding a permanent pipe of lead. To prevent acid solution entering iron piping in case of the valve leaking a half inch drain was provided in the bottom, which was open when the system was not in use.

Various tests have been made with fires which have been purposely kindled, and those you will find adequately described in the literature of the different firms dealing with foam systems.

Certainly, however, foam has been applied with the greatest success to fires in very difficult circumstances. I could give you several instances, but I will be content with one or two. A big fire, due to lightning, took place in 1916 in the Gulf Refining Company's storage tanks in Texas. Three tanks with a total content of 37,686 barrels were on fire; the foam system operated automatically and extinguished the fire in a few minutes, with a loss of only 191 barrels of oil and damages limited to the wooden tank roofs and the top rings of two tanks. Another instance was a fire which occurred in a Trumble plant, where a split heater allowed oil to fall straight into the furnace. Within three or four minutes the foam pumps were working and in six minutes two streams of foam were available, and the flames extinguished except those from the oil dripping into the furnace, but these were dealt with by steam and two streams of foam introduced through the peep-holes. A little over 700 gallons of each solution were used.

In September, 1919, a great oil fire occurred at a refinery situated at Long Island. An all steel tank at first caught fire, and oil poured out through an 8-inch connexion which became fractured, and a large volume of blazing oil flowed around. This could not be dealt with by the foam system, but foam was pumped into twelve other tanks situated right in the blaze, and these were preserved. The supply of foam ran out, in part due to breaks in the pipe-lines causing heavy loss, but when fresh solutions had been made two tanks which had been blazing for four days, and were very hot, were extinguished in about twenty minutes. No better proof of the efficacy of foam could be furnished.

Fires on board oil-carrying and oil-burning ships call for some brief reference. The greatest risk with tankers is when loading or discharging, but the control of these operations being in the hands of experienced men fully conversant with the conditions and risks accidents are of very rare occurrence. Steam lines to the various compartments are usual, thus the United States Department of Commerce Steamboat Inspection Service requires steam pipes of not less than 1½ inches diameter to each hold, and separate compartment of same, and steam pipes of not less than ¾-inch diameter to all lamp lockers, oil rooms, etc. The valves controlling the steam lines have to be in an easily accessible house, in which the operator is well protected from heat and smoke.

Foam systems are fitted in some tankers and undoubtedly this leads to a great reduction of the fire risks.

With oil-burning ships stoke-hold fires may arise through oil leakage in a pressure system, especially at flanged joints. There is also some risk in case of collision or grounding of oil being flooded into the stoke-hold. In the Report of the Board of Trade Committee on the dangers of fire in passenger ships burning oil fuel

(1920) it was laid down that provision for the discharge of steam to the lower parts of the boiler room should be made, the control valves being outside the boiler-room. In each stoke-hold 10 cub. ft. of sand, sawdust impregnated with bicarbonate of soda, or other approved dry material for fire extinction should be provided, and chemical fire extinguishers in any specially confined and dangerous space.

The U.S.A. regulation requires all vessels over 500 tons gross using oil fuel to have in each stoke-hold a metal container, holding 50 gallons of sand, with scoop or shaker, and two or more approved fire extinguishers. In vessels of 500 tons or under, 25 gallons of sand and one extinguisher.

The Board of Trade Committee did not insist on the use of foam systems although they have strongly recommended their adoption. Some of the largest of the shipping companies who have recently converted their ships from coal to oil burning, forestalled the recommendations of the Board of Trade Committee, and have installed adequate foam plants on their ships.

In conclusion I should like to mention the novel method of extinguishing natural gas fires by means of high explosives, a method which has proved effective when all others have failed. What was probably the largest gas blaze ever experienced occurred at one of the Standard Oil Company's wells at Taft, Cal., on July 26th, 1919. It was estimated that 180,000,000 cub. ft. of gas escaped in 24 hours. The rush of gas, carrying shale and sand, was so great that in two hours the friction had made the casing hot enough to fire the gas, and a column of burning gas arose, 300 ft. high, and at 100 ft. altitude about 50 ft. across. So intense was the heat that a thermometer reading up to 300° F. was burst at a distance of 250 feet. To cope with the blaze most extensive steam and water lines were laid; finally there were 21 3-inch lines; 9 4-inch lines; 20 boilers and 11 rotary pumps at work to deliver steam, water and mud, and even carbon tetrachloride. All these were unable to extinguish the flame. Finally Ford Alexander rigged up a line which enabled him to draw a charge of blasting gelatine to the vicinity of the flame and its explosion immediately extinguished it.

My grateful thanks are due to some of my friends in the Institution who have given me much useful material, which has been incorporated in this address, which, I hope, will serve the purpose with which I delivered it—namely, that it will stimulate some of our members with experience of fires in oilfields (particularly well fires) and in big storage plants to come forward and give their personal experience of the practical side of the subject.

The President said it now only remained for him in vacating the Chair, to express his thanks to the Council, and to the members

of the Institution for the very cordial support they had accorded to him during his two years of office as President of the Institution. It was now his duty and pleasure to ask the new President, Mr. Barringer, to take the Chair. Mr. Barringer, who was one of the oldest and most active members, was very well-known to all the members of the Institution. Those who had had the pleasure of serving on the Council with Mr. Barringer knew what a great deal of time he had devoted to the interests of the Institution, and how at great inconvenience to himself, he had attended not only many Council meetings, but Committee meetings, which were held in connexion with the conduct of the affairs of the Institution. Mr. Barringer brought a new experience to bear on the office of President, as he would be the first engineering President of the Institution, and for that reason alone, apart from any other, he was sure the members most heartily welcomed the appointment of Mr. Barringer to the position which it now afforded him the greatest pleasure to ask him to occupy.

(The Chair was then vacated by Prof. Brame, and taken, amid very hearty cheering, by the new President, Mr. Herbert Barringer.)

The President (Mr. Herbert Barringer) said he desired, in the first place, to thank Prof. Brame for the very kind way in which he had inducted him to the Presidential Chair, and the Members for the very cordial way in which he had been received. Prof. Brame had set a very high standard for the President, and personally he relied upon the kindness and the assistance of the members to enable him to maintain that standard. At any rate, he assured the members that he would do his utmost to uphold the dignity of the Chair. He was deeply conscious, not only of the honour bestowed upon him by the election as President for the ensuing session, but also of the honour that had been done to the engineering profession in his appointment, because, as Professor Brame had said, he was the first, but he hoped not the last, engineering President of the Institution. He was perfectly certain that the members, after hearing Prof. Brame's valedictory address, would be very pleased that he (Mr. Barringer) did not fall in with Prof. Brame's strategy, and that he remained adamant so far as insisting upon Prof. Brame delivering a valedictory address was concerned. It was well known that a Presidential address was not open to discussion, but he was sure the members would agree with him that they had seldom had the privilege of listening to such a masterly summary of any subject. He had compressed within a comparatively short time numerous instances of the dangers that existed from fire and explosion, even warning them against the risks that occurred in connexion with their feline friends. He had also detailed most of the means that were now recognised as effective in overcoming fire; and he was sure that when the address was

printed it would establish a very high standard among Presidential addresses, and would prove most valuable, especially to men in the field. The very pleasant duty now devolved upon him of asking the members to offer a very cordial vote of thanks to the retiring President for the work he had performed during his two years' term of office. The members knew the efficient and the charming way in which Prof. Brame had conducted the meetings; he had put everyone at ease. No one but those on the Council had any idea of the amount of work that Prof. Brame had done, and the time he had devoted to the interests of the Institution. Most of the members had only seen him presiding at the meetings, but he could assure them that that was only a very small portion of the work he had performed, and the success which the Institution had achieved was largely due to his very efficient guidance. Some two years ago Sir Frederick Black made the prophecy—personally he did not know that it was a rash one—that in two years time the membership would have increased very considerably. He did not know whether Sir Frederick mentioned any particular figure whether it was as to the square or the cube of the time, but he thought it might safely be said that Sir Frederick's prophecy had been fulfilled. He asked the members to accord a very hearty vote of thanks to Prof. Brame, not only for the very valuable services he had rendered to the Institution during the past year, but also for his address on the present occasion. He thought the members would agree with him, after reading the Annual Report and the Balance Sheet, the latter of which Mr. Adams had explained, that Prof. Brame had had a most successful two years of office, and that they were very sorry to lose him.

The resolution was carried by acclamation.

Prof J. S. S. Brame, who was very cordially received on rising to reply, thanked the members for the cordial manner in which they had responded to the President's remarks. He hoped to be spared to serve the Institution in whatever way he could for a good many years yet. He could only say how much he appreciated the remarks Mr. Barringer had made, and the very cordial way in which the members had passed the vote of thanks which had been accorded to him for his services.

The meeting then terminated.

A Method for Expressing the Value of Mixing Agents between Hydrocarbons and 95 per cent. vol. Alcohol.

By W. R. Ormandy and E. C. Craven.

Apart from the petrols of Eastern origin naturally rich in aromatic hydrocarbons, the bulk of the motor spirits on the market are not able to withstand the extremely high compression to which they are subjected in the modern type of engine. The supplies of aromatics from coal tar sources are extremely limited, and attempts have therefore been made to discover some body which can be produced in large quantities cheaply, and which would have a similar effect to the aromatics in preventing detonation. Ethyl alcohol appears to be about the only practicable substitute for benzole, as it will stand an even higher compression than the latter, and is available—or could be available—in any desired quantities. Unfortunately, the alcohol of commerce cannot well be produced containing less than 4½ per cent. of water by volume, owing to the fact that a binary mixture of minimum boiling point is obtained. The presence of this water prevents the miscibility in small proportions of alcohol with petrol, and attempts have therefore been made to find a third body which will act as a mixing agent between the aqueous alcohol and petrol. From time to time obviously exaggerated claims have been made for various bodies—usually patented—for this purpose. A great many of these bodies were investigated as mixing agents in this laboratory long before they were "boosted."

The competition at Béziers gave a great impetus to the search for these mixing agents, but no very striking ones appear to have been discovered up to the present. It is of course desirable that there should be some means of determining quantitatively the relative value of any proposed mixing agent, and the present note deals with an approximate solution of this question.

Heptane was used as a standard hydrocarbon. Mixtures of heptane and 95 vol. alcohol were made. When a small proportion of the alcohol was replaced by an equal volume of any one given mixing agent it was found that the change in separation point Δt was approximately proportional to the volume of mixer added and inversely proportional to the volume of alcohol originally present. Thus if M = % by vol. of mixer replacing equal volume of alcohol,

A = % by vol. of alcohol before replacement.

$$\Delta t \propto \frac{1}{A}$$

$$\Delta t \propto M$$

$$\text{Thus } \Delta t = K \frac{M}{A}$$

The constant $K = \frac{\Delta t A}{M}$ might be called the mixing value of the mixing agent. If the separation temperature is lowered by the mixer Δ t and K can be reckoned positive, *i.e.*, if K is positive the mixing agent has a positive action in assisting solubility.

The following figures demonstrate the relations given, and the degree of constancy obtained for K for various bodies :—

SOLUBILITY HEPTANE, ALCOHOL 95% VOL. + CRESOL.

Alcohol 10%

Heptane. %	Cresol. %	Sept. Pt. °C.	Δ t / M	Δ t A / M
90	0	about 77		
„	2	42	All very indistinct.	
„	2	45?		
„	4	37?	10	100

Alcohol 15%

Heptane. %	Cresol. %	Sept. Pt. °C.	Δ t / M	Δ t A / M
85	0	69½	—	—
„	2	51½	9·0	138
„	4	38	8·0	120
„	6	23	7·7	116
„	8	8	7·7	116
		Mean	8·1	122

Alcohol 20%

Heptane. %	Cresol. %	Sept. Pt. °C.	Δ t / M	Δ t A / M
80	0	61	—	—
„	2	48	6·5	130
„	4	34	6·7	134
„	6	26	5·8	116
„	8	12	6·1	122
		Mean	6·3	125

Alcohol 30%

Heptane. %	Cresol. %	Sept. Pt. °C.	Δ t / M	Δ t A / M
70	0	48	—	—
„	2	39·5	4·3	129
„	4	31	4·3	129
„	6	23·5	4·1	123
„	8	16	4·0	120
		Mean	4·2	125

Alcohol 40%

Heptane. %	Cresol. %	Sept. Pt. °C.	Δ t / M	Δ t A / M
60	0	40	—	—
„	2	33·5	3·3	132
„	4	27·5	3·1	124
„	6	21·5	3·1	124
„	8	15·5	3·1	124
		Mean	3·2	126

SOLUBILITIES HEPTANE, ALCOHOL 95% + AMYL ALCOHOL.

	Heptane.	Amyl Alcohol.	Sep. Pt. °C.	Δ t M	Δ t A M
Alcohol 15%	%	%			
	85	0	69½	—	—
	,,	2	50	9·7	145
	,,	4	27	10·6	158
	,,	6	0	11·6	174
	,,	8	−37	13·3	199
			Mean	11·3	169
Alcohol 20%	%	%			
	80	0	61	—	—
	,,	2	45	8·0	160
	,,	4	28	8·2	164
	,,	6	6	9·1	182
	,,	8	−19	10·0	200
			Mean	18·8	176
Alcohol 30%	%	%			
	70	0	48	—	—
	,,	2	38	5·0	150
	,,	4	25	5·7	171
	,,	6	10·5	6·2	186
	,,	8	−5	6·6	198
			Mean	5·9	176
Alcohol 40%	%	%			
	60	0	40	—	—
	,,	2	31·5	4·2	168
	,,	4	23	4·2	168
	,,	6	12	4·7	188
	,,	8	1·5	4·8	192
			Mean	4·4	179

A.

SOLUBILITIES HEPTANE, ALCOHOL 95% VOL. + WATER.

	Heptane.	Water.	Sep. Pt. °C.	Δ t M	Δ t A M
Alcohol 30%	%	%			
	70	0	49·5	—	—
	,,	0·25	59·0	−38·0	−1110
	,,	0·5	68·3	−37·6	−1130
Alcohol 40%	%	%			
	60	0	42·3	—	—
	,,	0·5	55·2	−25·8	−1020
	,,	1·0	65·8	−23·5	−940
Alcohol 50%	%	%			
	50	0	36·1	—	—
	,,	0·5	46·3	−20·4	−1020
	,,	1·0	55·3	−19·2	−960
	,,	1·5	64·0	−18·6	−960

It will be noticed that k in the case of amyl alcohol increases somewhat as the replacement increases. As in practice only a small proportion of mixing agent could be considered the value arrived at by using such amounts only could be considered.

The following table gives the value of $\frac{\Delta t A}{M} = K$ determined

in most cases for mixtures containing :—

85 vols. hydrocarbon.
10 „ 95 vol. alcohol.
5 „ mixing agent.

Mixing agent.		K Heptane.	Petrol No. 1.
Benzene		3	1
Toluene		—6	—
m-Xylene		—18	—
Turpentine		0 about	<0
Heptane		—11	—
Cresol		123	114
Anilin		51	26
Methyl alcohol ..		—24	—30
Ethyl „	95 vol.	0	0
Ethyl „	100 „	72	72
Propyl „ ..		90	70
Butyl „ ..		168	144
Amyl „ ..		170	150
Hexyl „ ..		47	—
Ether		small	3
Acetone		41	18
Ethyl acetate ..		small	27
Cyclo-hexanol ..		201	150
Acetaldehyde ..		—20	—
Water		—1000	—

It will be noticed that the value of K is not rigorously constant, but it is sufficiently so to give an idea as to the relative value of a mixing agent. Possibly if the figure were expressed as a water coefficient—that is to say, the ratio of the separation temperature differences for equal amounts of mixing agent and water on the same heptane-alcohol mixture—these figures would be more clearly understood. For example, the water coefficient for cresol would be about 0·12—that is to say, for an addition of 1 per cent. water to an alcohol-petrol mixture 8 per cent. of cresol would have to be added in order to prevent the separation point from rising. No body so far examined is more than one-fifth part as effective in preventing separation as water is in bringing it about, and it is extremely unlikely that any such body will be found.

It may be of some interest to speculate on the manner in which these mixing agents assist the miscibility of a hydrocarbon on the one hand, and aqueous alcohol on the other. It will be noticed that the most effective mixing agents are those having hydrocarbon residue groups combined with an hydroxyl group. It may be that the petrol is attracted by the hydrocarbon end of the body, and the aqueous alcohol by the OH group.

These notes are extracted from the work on fuels which is being carried out for the Distillers' Company, Ltd., and the Fuel Research Board of the Department of Scientific and Industrial Research, to whom the authors are indebted for assistance.

Free Sulphur in Motor Fuels, etc.

By

W. R. Ormandy and E. C. Craven.

Trouble is sometimes experienced in automobile running by the heavy corrosion of copper in very much less degree of brass parts which come into contact with liquid fuel. Floats, gauzes and feed tubes have been submitted to us which were thickly coated with a layer of black copper sulphides. Such deposits lead to choking of gauzes and jets and the deep pitting we have seen on thin metal parts after only a few months use on a particular fuel showed that continued use would probably have resulted in complete destruction.

There can be little doubt that this corrosion arises from the free elementary sulphur which appears to be present in solution to a greater or less extent in all the hydrocarbon fuels on the market. The presence of this sulphur was shown by the following experiment:—

Two hundred c.c.'s of a good grade petroleum spirit, the free sulphur content of which had been determined at 6 mg. per 100 c.c.'s, was evaporated in a stream of air at about 50° C. down to small bulk, and the evaporation completed on a watch glass on the water bath. A small gummy residue was left. On examining this under the microscope numerous highly refracting globules were seen distributed through the film of oily matter. On scratching with a fine wire these globules crystallised to a yellow solid. This behaviour is highly characteristic of free sulphur.

The existing specifications and tests for motor fuels, so far as we are aware, do not deal in quantitative fashion with this free or reactive sulphur. Various qualitative tests have been proposed from time to time, but none of them are entirely satisfactory.

The copper dish test appears to be largely in use in the laboratories of the oil companies, and consists in evaporating 100 c.c.'s of spirit to dryness in a hemispherical copper dish on the water bath. The presence of elementary sulphur is indicated by a grey or black film on the dish. Gum forming constituents are also indicated by the test.

A variant of this test consists in performing an Engler distillation having present in the flask a strip of clean electrolytic copper foil, 2 cms. by 1 cm. The original suggestion was that a note of the temperature or of the percentage distilled should be made when blackening of the foil occurred. We have not found it possible to attach any meaning to such figures, especially when spirits of a different distilling range are being compared, especially for example,

in the case of motor benzole as against petrol. It has been found better to complete the Engler distillation and then examine the copper strip. Further reference will be made to this test in relation to the quantitative method to be described.

Other variations of the copper test appear to be in use but we have no details. We have tried refluxing the spirit to be tested in the presence of copper turnings, but the result did not appear to be likely to lead to a quantitative method.

The Doctor test and the sulphuric acid test do not appear to be true tests for sulphur, either free or combined. The former may indicate H_2S, and some specially unstable compounds probably containing –SH groups, but otherwise is not relevant to the present subject.

In approaching the problem of the determination of free sulphur we were hopeful at the outset of finding a volumetric method. To this end the following lines of attack were tried.

1. Refluxing with alcoholic potassium cyanide. The alcohol and spirit was distilled off, and the thiocyanate estimated by iron alum and silver nitrate as in the sulphur method of Davies and Foucar. The results were very erratic, and in most cases it was impossible to judge the end point.

2. Shaking for long periods with aqueous potassium cyanide. The same difficulties were found in titration and in addition the extraction of sulphur was only partial.

3. Shaking out with aqueous sodium sulphite solution. It was hoped that thiosulphate would be formed which could be titrated in the usual manner. The extraction was found to proceed too slowly.

4. Shaking with metallic sodium or sodium amalgam. This was tried after the mercury method about to be described was worked out. The sodium sulphide formed was brought into aqueous solution and estimated by acid and iodine. It was found that the results were low on petrols, and that with benzols part of the combined sulphur was attacked.

5. Treatment with yellow phosphorus was tried in the hope that phosphorus sulphide—P_2S_3—would be formed, but negative results were obtained on testing with cadmium acetate solution.

Finally, it has been found necessary to proceed on gravimetric lines. It is well known that the presence of free sulphur in carbon disulphide can be determined by shaking with mercury. Black mercuric sulphide is formed in a very finely-divided state, and remains suspended in the liquid. Trying this method on petrols and motor benzoles it was found that all gave a more or less heavy sulphide suspension. Distinct blackening occurs with a free sulphur content much smaller than 1 mg. per 100 c.c.'s. The problem was obviously to find some method of separating the

mercuric sulphide and estimating the sulphur in it. After some trials the method finally evolved was as follows :—

100 c.c. of the spirit* to be tested are put into a dry stoppered bottle and shaken vigorously with about 3 c.c. of mercury. The mercury usually breaks up into a sort of sludge and the spirit becomes black with suspended sulphide. The shaking is continued for 10-15 minutes, or until the excess mercury coagulates, which indicates that practically the whole of the sulphur has been removed. Dilute hydrochloric (1–100) acid is now added, and the mixture shaken again. This treatment causes the mercury sulphide to change from a somewhat colloidal form, in which it would pass through a filter, to a coagulated, easily filtered form.

The whole is now filtered under vacuum through a large wet asbestos plug. The sulphide is retained and the spirit and acid together with the bulk of the metallic mercury pass through. After washing a few times with more of the dilute acid in order to remove as much as possible of the adhering spirit, the asbestos plug is removed by a pointed glass rod to a beaker. The walls of the funnel are washed down on to the plug with strong hydrochloric acid, using about 25 c.c. About 0.5 g. of potassium chlorate is added when on agitation the sulphide will dissolve up, leaving, as far as can be found, no residue of free sulphur. The beaker is heated up gently to expel chlorine and the solution diluted and filtered off. The sulphate estimation is now carried out by barium chloride in the usual manner.

It is useful to remember when calculating the result, that $BaSO_4X\ (\frac{1}{8} + \frac{1}{80}) = S$.

The method was tested twice, using known quantities of sulphur. In the first test three determinations were made of the free sulphur content of a certain petrol with the following results :—

Free S. per 100 c.c.	
1. 1·0 mg.	mean 1·0 mg. S per 100 c.c.
2. 0·9 mg.	
3. 1·1 mg.	

To 100 c.c. of this petrol 19 mg. of roll sulphur were added, making a solution containing 20 mg. per 100 c.c. Mixtures were made up with this, and the following results obtained :—

Sulphur taken, mg.		Sulphur found, mg.
1·0	..	—
2·0	..	2·1
3·0	..	2·9
4·0	..	3·7
5·0	..	4·7

* Heavy oils may be diluted with mercury washed spirit.

It was thought that possibly the slightly low results were due to insoluble sulphur in the roll sulphur taken, and a second test was made using sulphur recrystallised from warm benzene. The spirit used was washed with mercury and contained only a negligible amount of free sulphur. The results were as follows :—

Sulphur taken, mg.		Sulphur found, mg.
1·0	..	1·0
2·0	..	2·1
3·0	..	3·0
4·0	..	4·3
5·0	..	5·3
6·0	..	6·2
7·0	..	7·0
10·0	..	9·6

There thus appears to be a natural error of 0·2–0·3 mg. S. in the determination.

In all cases blank determinations should be made, but it has been found that with the usual analytical reagents the blank is negligible.

The results obtained by the method on various bodies are tabulated below, and wherever the copper strip test has been made the result has been put in. The condition of the strip at the completion of the Engler test has been taken as the criterion and the results expressed on the following scale.

GOOD. No discoloration, or only peacock or brown tints.

FAIR. Blackening but no scaling, even on bending strip.

BAD. Black scaling on bending strip.

VERY BAD. Scaling before finish of distillation.

Sample.		Free sulphur, mg. per 100 c.c.	Copper strip test.
Petrols.			
No. 1.	A.	6·3 ..	Very bad
,,	B.	3·1 ..	Very bad
,,	C.	3·3 ..	Very bad
,,	D.	trace ..	Good
,,	E.	0·4 ..	Good
,,	F.	1·2 ..	Bad
,,	G.	1·0 ..	Bad
No. 3.	A.	5·5 ..	Very bad
,,	B.	3·0 ..	Very bad
Shale petrol	.. ..	0·5 ..	Fair
Pintsch gas spirit, crude	.. ..	3·9 ..	Very bad
,, ,, ,, refined	.. ..	trace ..	Good
Benzine distillate	.. .. ..	1·1 ..	Bad
American Navy specification	.. ..	6·5 ..	Very bad
Heptane, unrefined	.. .. ..	0·7	

Benzols.

English A.	1·0	Fair
„ B.	trace	Good
„ C.	trace	Good
Foreign A.	4·9	Very bad
„ B.	3·3	Very bad
Mixture	2·0	Very bad

White Spirits.

A.	trace	Good
B.	7·9	Very bad

Kerosenes.

Mexican	4·9	Very bad
American	2·8	Very bad
Borneo	trace	Good
Extract	0·3	Good
Unrefined Kerosene	69·0	Very bad

Alcohol Fuels.

95% alcohol	nil	Good
P.M.S. 1	0·4	Fair

The S. contents of alcohol depend entirely on the added ingredients.

Heavy Oils.

Spindle oil	0·4
Medium lubricating	nil

Crude Oils.

Borneo	0·9
Mexican	2·6
Trinidad waxy	trace
„ non-waxy	nil
Lignite tar	10·7

It will be noticed that as regards the copper strip test, blackening occurs with a concentration of slightly over 1 mg. sulphur per 100 c.c., and scaling at perhaps 2 mg. Any spirit containing not more than 1 mg. free sulphur per 100 c.c. might be considered commercially free. It may be mentioned that after shaking a spirit with mercury the washed spirit gives no positive copper strip test. In general, the American spirits tested appeared to contain somewhat less free sulphur than the spirits of Oriental origin. With heavier products the reverse was the case.

The free sulphur content is of particular importance when mixtures are made with alcohol. Possibly the slight acidity of alcohol serves to remove oxide films and so render metal surfaces more susceptible to attack by the dissolved free sulphur. The enhancing

of the corrosion effect has been observed on the large scale, and may also be shown by the copper strip test. Two mixtures were made :—

A. 50 c.c. benzole 5 mg. S. per 100 c.c.
50 c.c. sulphur free benzole.
B. 50 c.c. benzole 5 mg. S. per 100 c.c.
50 c.c. alcohol 95% vol. strength.

Blackening of the copper strip was noticed.

	°C.	% distilled.
Mixture A. ..	95 ..	80
„ B. ..	68 ..	17

Hence, since the concentration of sulphur was the same in the two mixtures, the experiment shows that the blackening is accelerated by the presence of alcohol. A further portion of mixture B. was shaken well with mercury. The filtered spirit gave only peacock tints with the copper strip test.

A further experiment in which denatured alcohol (P.M.S. 1) was used instead of plain alcohol, gave very similar results, the copper strip blackening at 70° C., 67 per cent. having passed over.

A few trials were made on the possibility of removing the free sulphur by physical means. 50 gms. of the absorbing material were shaken for half-an-hour, with 125 c.c. of a petrol containing 6·3 mg. of sulphur per 100 c.c. 100 c.c. of the petrol was filtered off and the sulphur determined. The results were :—

	Free sulphur.
After bauxite (as received)	5·5
„ „ (roasted)	3·3
„ silicagel (as received)	6·3
„ „ (roasted)	5·1

Slight absorption thus seems to occur.

As regards the origin of the free sulphur in these fuels we have not been able to arrive at any certain conclusions. From the table it will be noticed that four crude oils contained only small amounts of free sulphur. The fractions up to 300° C. were distilled from Borneo and Trinidad crudes, and only showed traces of free sulphur by shaking with mercury. It was unfortunately impossible to get the Mexican crude to distil.

The possibility of sulphur being set free by the action of light and air on combined sulphur-containing fuels was tested to some extent by exposing four mercury treated samples in stoppered bottles in the laboratory window for 28 days. Sulphur tests then showed :—

Petrol	Doubtful trace
Kerosene	Doubtful trace
Mixed alcohol fuel	Doubtful trace
Benzole	0·4 mg. per 100 c.c.

The results are somewhat as expected, since benzole contains carbon disulphide, formation of free sulphur in which is well known.

The comparative freedom of crude petroleum from free sulphur leads one to suppose that during the refining the chemical treatment either sets free sulphur or produces sulphur compounds which give rise to free sulphur during the subsequent operations. It is quite obvious, however, that this is a matter which can only be followed up properly in a refinery.

The authors desire to express their thanks to various oil companies to whom they are indebted for many of the samples tested, to Dr. H. J. S. Sands for suggestions in regard to methods, to Mr. Connolly for much careful analytical work, and to the Distillers Co., Ltd., and the Fuel Research Board of the Department of Scientific and Industrial Research Board for financial assistance in carrying out this work.

REVIEWS

"The Business of Oil Production (1922)." Johnson, Huntley and Somers. London Publishers: Chapman and Hall, Ltd. Price 17s. 6d.

The present work is, in part, a continuation of Johnson and Huntley's *Principles of Oil and Gas Production* (1916), and, in part, an expansion of certain economic subjects dealt with very briefly in the earlier work. It is to be regarded as a series of articles rather than a sequential whole, but this in no way detracts from its general merit. The technology of drilling and kindred matters is dealt with only to such extent as is necessary to illustrate its relation to economic and administrative issues. Whilst portions of the subject matter relate peculiarly to American conditions, the sections devoted to such subjects as company administration, organisation of personnel, financial and costing methods, which are written with much shrewdness and knowledge, are of wide applicability and will constitute very profitable reading, particularly for those whose interests run in administrative and executive channels.

A succinct and interesting review of the Mexican situation concludes with the view that production in existing fields may continue long enough to enable the soundest companies to re-establish themselves in other less accessible areas, in which the oil is likely to be of higher quality, but that higher working and transport costs, and the probability of considerably smaller well averages leave little hope of any recurrence of boom conditions.

A summary is given of petroleum legislation current in North and South America, which, though of present-day interest, may prove of somewhat ephemeral value. In one or two cases, *e.g.*, Peru and Venezuela, the information is already obsoleted by the passage of later legislation.

The preface should apparently be dated 1922, instead of January, 1912.

A. C. H.

"Chart of the Mexican Oilfields, 1923." In four sheets. Cull and Co.

The four sheets comprise a very useful map of Mexico, on a scale of about 2 inches to 25 kilometres, showing the location of the various places where exploration and exploitation of oil-fields is being carried out, the position of prospective oil areas, also pipe-lines, railways, and the principal towns. The topographical and geographical information might with advantage be extended and in some cases the prospective oil-fields as shown on the key-map, and on the large map, are not consistent.

A. W. E.